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American Foundryman

"The FOUNDRYMEN'S OWN MAGAZINE"

Sand preparation at Northwestern University foundry

January 1946—Cast Iron (p. 20). Pattern Equipment (p. 30). Non-Destructive Testing (p. 38). Malleable Sand (p. 42). Sand Toughness (p. 50). Refractories (p. 55). Sand Control Cumulative Curve (p. 65). Educational Program (p. 90).

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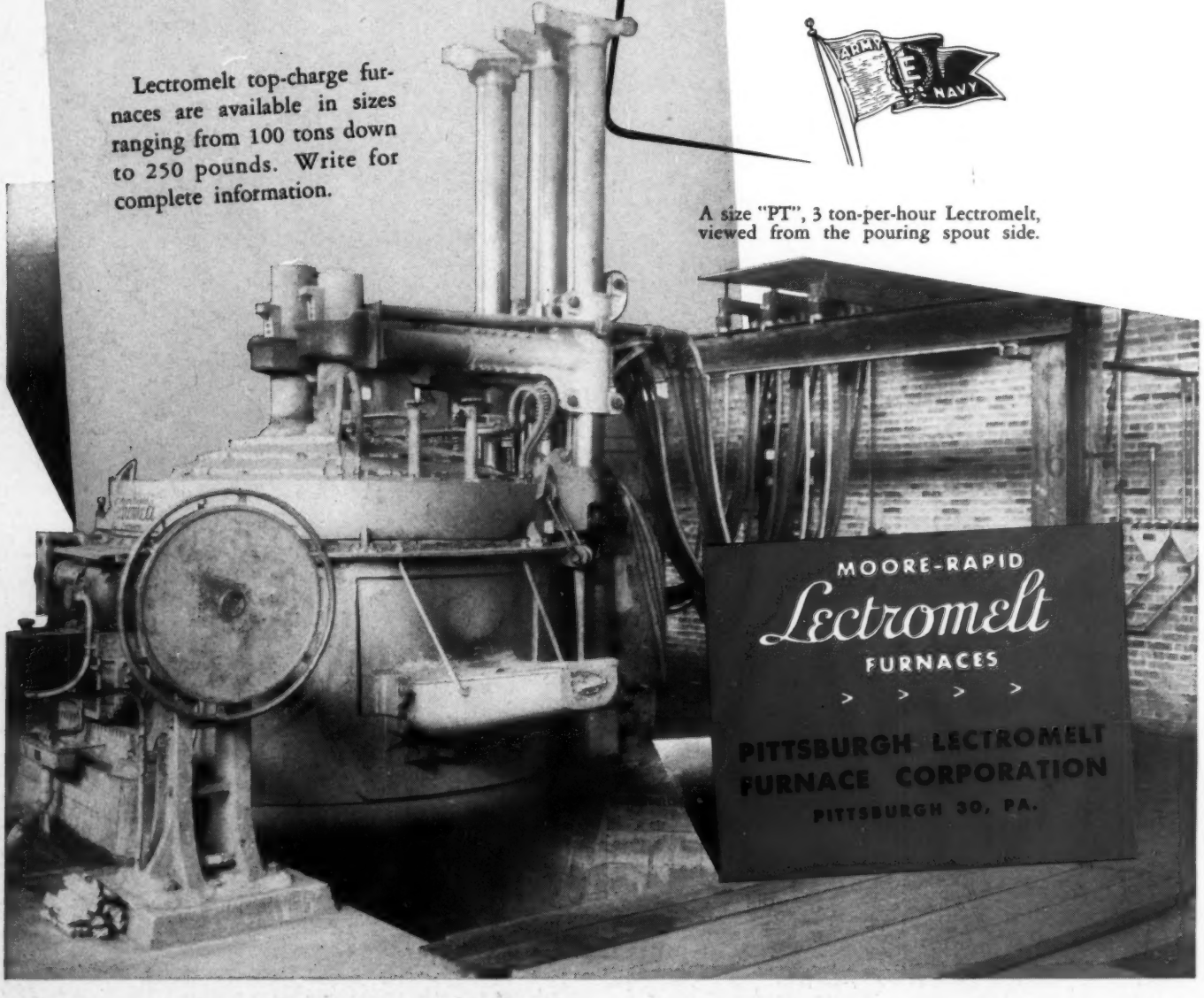

American Foundryman

JANUARY, 1946 VOL. IX, NO. 1

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WHO ARE THE AUTHORS *In This Issue?*

The men whose names are shown on these two pages deserve the thanks of the industry for their contributions to the 1945 "Year-'Round Foundry Congress" . . . in many cases, completed in spite of cancellation of the Detroit convention.

H. F. Taylor

Author (with associate R. E. Morey) of *"Cumulative Curve in Foundry Sand Control"* . . . A native of Michigan, Mr. Taylor was born in Leslie . . . Received his Bachelor of Science and Master of Science degrees from Michigan State College of Agriculture & Applied Science, East Lansing, Mich. . . . At present is on leave from the Naval Research Laboratory, Washington, D. C., studying for his Doctor's degree at Massachusetts Institute of Technology, Cambridge, Mass., as Research Fellow, Gray Iron Founders Society, Cleveland . . . Started his business career with the Michigan State Highway Department as a clerk . . . Was connected with Michigan State College, foundry department, as molding instructor and was later appointed instructor in the metallurgy department . . . Became affiliated with the Michigan Sugar Co., Lansing, Mich., as chemist . . . Is a staff member of the Naval Research Laboratory and Chairman, Chesapeake chapter.

H. W. Dietert

Author of paper herein on *"Effect of Table Rise (Strain Rate) on Hot Strength of Bentonite Bonded Sands"* . . . Born in Texas, Mr. Dietert received his early technical training at Iowa State College, Ames, Iowa . . . Graduated in 1920 with a Bachelor of Science degree in mechanical engineering . . . After two years at the Philadelphia works, Westinghouse Electric Corp., he became instructor in charge of shops at Rice Institute, Houston, Texas . . . During 1922-23 he carried on graduate work at the University of Illinois, Urbana, receiving his Master of Science degree . . . Joined the engineering staff, U. S. Radiator Corp., Detroit, as research engineer . . . Later was made chief engineer . . . Resigned from his position to form his own company . . . Was awarded the Wm. H. McFadden Gold Medal at the 1940 A.F.A. convention for his work in promoting interest in foundry sand research and control . . . Has served almost continuously on the A.F.A. Foundry Sand Research Project since its start in 1921 as a member of numerous sand committees.

R. E. Morey

See, in this issue, *"Cumulative Curve in Foundry Sand Control"* . . . Co-author is H. F. Taylor . . . Mr. Morey was born in Maywood, Ill. . . . Received a chemical engineering degree from Rensselaer Polytechnic Institute, Troy, N. Y. . . . Began his industrial career as junior assistant highway engineer, New York State Highway Department, in 1930 . . . Became a melter at the U. S. Naval Gun Factory, Washington, D. C. (1934) . . . Three years later assumed his present position as metallurgist, Naval Research Laboratory, Washington, D. C. . . . Is active in the A.F.A. Foundry Sand Research Project as a member of the Committee on Grading and Fineness . . . Has written articles for the trade press on molding sands . . . Besides his membership in A.F.A. he is a member of Washington Society of Engineers.

J. W. Juppenlatz

In this issue: *"Other Non-Destructive Methods of Testing"* . . . Born in Springfield, Mass. . . . Attended Massachusetts Institute of Technology, Cambridge, Mass., for one year and has taken metallurgical courses during summer sessions . . . Started his business career in 1921 with the Chapman Valve Mfg. Co., Springfield, Mass., as chief metallurgist . . . Began a three-year association with Midvale Co., Philadelphia, in 1929 . . . One year later (1933) became connected with New Jersey Silica Sand Co., Millville, N. J., as a sand engineer . . . Became associated with Link Belt Co., Philadelphia, in 1934 as metallurgist . . . Was appointed chief metallurgist, Treadwell Engineering Co., Easton, Pa., in 1935 . . . At present is chief metallurgist, Lebanon Steel Foundry, Lebanon, Pa., and has been with this firm since 1942 . . . Has written quite extensively for the trade press and has been a frequent speaker before various technical societies . . . An A.F.A. Steel Division member and associated with the Committee on Non-Destructive Testing . . . Holds memberships in AIME, ASM, ASTM, SAE, Steel Founders Society and A.F.A.

H. W. Lownie, Jr.

Co-author (with W. E. Mahin) of a paper on *"Microstructure Related to Properties of Cast Iron"* . . . Born in Buffalo, N. Y. . . . Attended Purdue University, La Fayette, Ind., and was graduated in 1939 with a Bachelor of Science degree in chemical engineering . . . Appointed foundry control engineer, Westinghouse Electric Corp., East Pittsburgh, Pa. . . . Obtained his Master of Science degree in metallurgical engineering from the University of Pittsburgh Evening School, Pittsburgh, Pa., in 1943 . . . That same year, was appointed materials engineer at Westinghouse . . . Was later promoted to metallurgical engineer . . . Recently joined the staff of Battelle Memorial Institute, Columbus, Ohio.

H. A. Schwartz

See article in this issue *"Combustion Method for Sulphur Determination in White Cast Iron"* . . . Jointly written with James D. Hedberg . . . Mr. Schwartz was born in Oldham County, Kentucky . . . Advance education obtained from Rose Polytechnic Institute, Terre Haute, Ind. . . . Degrees received include Bachelor of Science (1901), Master of Science

(1903), degree of Mechancial Engineering (1905) and honorary degree of Sc.D. . . . Joined National Malleable Castings Co., Indianapolis, 1902 and remained at that plant until 1920; receiving numerous promotions . . . Was named director of research, National Malleable & Steel Castings Co., Cleveland, in 1920 . . . Dr. Schwartz is widely known for his many papers presented before meetings of technical societies . . . Has been the recipient of two medals — the A.F.A. John A. Penton Gold Medal and the E. J. Fox Gold Medal of the Institute of British Foundrymen.

W. E. Tharp

Author of, in this issue, *"Pattern and Allied Equipment — Design, Redesign, and Interchangeability* . . . Born in Kingston Mines, Ill. . . . In 1934 joined Caterpillar Tractor Co., Peoria, Ill., as a pattern apprentice . . . Following the completion of his four year apprentice course he was placed in the pattern design department . . . Became connected with Pioneer Tool Engineering Co., Detroit, 1940 . . . Returned to Caterpillar Tractor Co. one year later and was appointed apprentice instructor . . . The following year (1942) was made foundry technician.

W. G. Parker

Appearing in this issue: *"Some Aspects of Green Deformation and Sand Toughness in Sand Control"* . . . Author was born in Cross Fork, Pa. . . . Began his industrial career with Elmira Foundry Co., Elmira, N. Y., as a laboratory assistant in 1926 . . . Was named director of laboratory and sand technician for that firm in 1940 . . . Is a member of the A.F.A. Foundry Sand Research Project, Committee on Flowability . . . Member of A.F.A.

L. M. Nash

Author of paper *"Melting Magnesium Alloys"* . . . Born in Traverse City, Mich. . . . Attended Michigan College of Mining & Technology, Houghton, from 1926-29 . . . Started his industrial career with Dow Chemical Co., Midland, Mich., as laboratory assistant . . . Was transferred in 1936 to Dow's Bay City, Mich., plant as metallurgist . . . Three years later (1939) joined Magnesium Products, Inc., Los Angeles, as superintendent . . . In 1945 was appointed production manager, Magnesium Alloy Products Co., Los Angeles . . . Has written articles for the trade press concerning magnesium foundry practice . . . A.F.A. member.

James Thomson

Author of paper on *"Cleanliness and Safety in the Foundry"* . . . Born in Glasgow, Scotland . . . Attended Washington & Jefferson College, Washington, Pa. . . . His business career began when he became associated with American Steel & Wire Co. as a draftsman . . . Held a similar position with S. V. Huber and Lewis Foundry & Machine Co. . . . Was named plant engineer, United Engineering & Foundry Co. . . . Assumed the position of chief engineer with Hubbard Steel Foundry Co. . . . At present is chief engineer, Continental Foundry & Machine Co., East Chicago, Ind.

E. K. Pryor

Part author with L. R. Burke of A.F.A. paper *"Refractories for Electric Melting in the Ferrous Foundry"* . . . Mr. Pryor was born on May 18, 1907, in Camden, Ohio . . . Attended Ohio State University, Columbus, Ohio, 1925-28 . . . From 1929 to 1931 he attended the University of Arizona, Tucson, Ariz. . . . Obtained a Bachelor of Science degree in mining in 1930 and the year following (1931) received a Master of Science degree in metallurgy . . . Began his industrial career with American Rolling Mill Co., Middletown, Ohio, in 1928 as assistant metallurgist . . . Was appointed research fellow for the U. S. Bureau of Mines, Tucson, Ariz., 1930-31 . . . Until 1933 was research engineer with Miami Copper Co., Miami, Ariz. . . . The following year (1934) was associated with Pratt-Gilbert Co., Phoenix, Ariz., in an engineering and sales capacity . . . From 1941 until 1945 was connected with The Chas. Taylor Sons Co., Cincinnati, Ohio, as field engineer . . . Recently joined the staff of Battelle Memorial Institute, Columbus, Ohio . . . Has prepared talks on refractories for electric furnace service for A.F.A. and AIME meetings.

J. D. Hedberg

Author (with associate H. A. Schwartz) of current paper on *"Combustion Method for Sulphur Determination in White Cast Iron"* . . . Born in Falun, Kansas . . . Awarded his Bachelor of Arts degree in chemistry in 1925 from University of Kansas, Lawrence, Kansas . . . The following year became associated with Universal Portland Cement Co., Buffington, Ind. . . . From 1929 until 1943 was connected with Master Builders Co., Cleveland . . . Joined National Malleable & Steel Castings Co., Cleveland, in 1943 . . . Member of American Chemical Society.

L. R. Burke

Co-author, with E. K. Pryor, of A.F.A. paper on refractories . . . See: *"Refractories for Electric Melting in the Ferrous Foundry"* . . . Mr. Burke was born in New York City on December 15, 1912 . . . Attended Carnegie Institute of Technology, Pittsburgh, Pa. . . . Graduated from that institution in 1935 with a Bachelor of Science degree in engineering . . . Became affiliated with The Chas. Taylor Sons Co., Cincinnati, Ohio, the following year (1936) as a field engineer with headquarters in Pittsburgh, Pa.

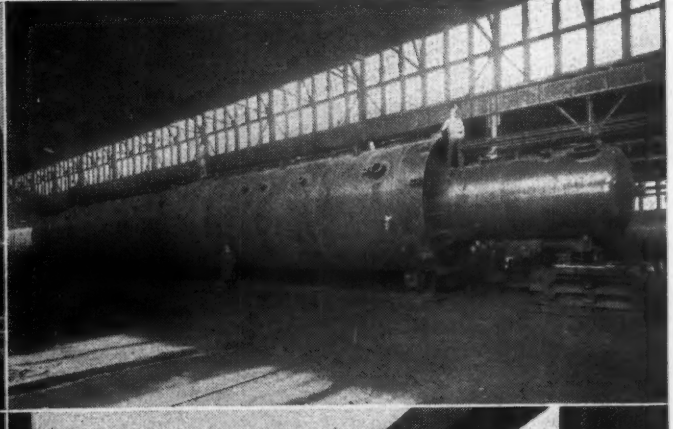
F. C. Rogers

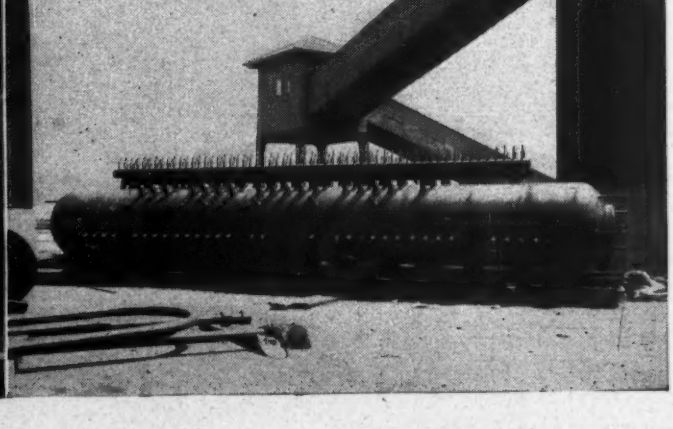
Superintendent, Olympic Steel Works, Seattle, Wash. . . . Author of mold drying paper in this issue: *"Sand Mold Drying with Propane-Gas Torches"* . . . Born in Vancouver, British Columbia, Canada . . . Bachelor of Science degree in chemical engineering was obtained from University of Washington, Seattle, Wash. . . . Joined Pacific Coast Testing Laboratory, Seattle, in 1933 as an analyst . . . A year later became connected with Holt Co., Seattle, as chemist . . . Was appointed chief chemist, Pacific Car & Foundry Co., Seattle, in 1936 . . . Named metallurgist (1939) for Olympic Steel Works and assumed his present position with that firm three years later . . . A member of ASM, Gray Iron Founders Society and Steel Founders Society.

W. E. Mahin

Joint authorship with H. W. Lownie, Jr., of paper *"Microstructure Related to Properties of Cast Iron"* . . . Mr. Mahin was born in Baltimore, Md. . . . Obtained his Bachelor of Science degree from University of Notre Dame, Notre Dame, Ind., in 1928 . . . Received his Master of Science degree in metallurgical engineering from Carnegie Institute of Technology, Pittsburgh, Pa. (1933) . . . Affiliated with Inland Steel Co., Indiana Harbor, Ind., on a part time basis during the summer months while attending college . . . Became associated with Vanadium Corp. of America, Bridgeville, Pa., in 1928 as research metallurgist . . . In 1936 joined Westinghouse Electric Corp., East Pittsburgh, Pa., and helped develop a metallurgical laboratory . . . Became section engineer, metallurgical section, for Westinghouse in 1939 . . . Mr. Mahin is serving as secretary of the A.F.A. Gray Iron Division and is a member of numerous gray iron committees of A.F.A.

MUSCLES FOR METAL GIANTS





Management--- Take Hold and Do the Job

I AM directing this short message to the foundrymen of America after just completing a lengthy report and an accompanying plea to the educational authorities of my home city. This plea is for assistance and help in encouraging a desirable type of youth to enter our local foundry plants for training in the castings industry.

The art of founding metal has long since passed the day when a strong back and a weak mind were considered by many as the main requirements for a young man about to embark on a period of foundry training. Many members of our industry have long since discarded any such conceptions of their future employees, and some have developed programs of training far above the average of the industry. A number of the larger cities also have cooperated with us by instituting methods of training and instruction which leave little to be desired.

The point to remember, however, is that we cannot as foundrymen shut our eyes to the fact that such outstanding examples are few and far between. A great deal remains to be accomplished before the average level of conditions, as applied to apprentice training, will rise.

The problem is one that rests mainly with top management of our foundries and concerns many associated factors. A frank discussion of such related items as working conditions, shop practices and broader thinking about the future of the foundry industry are essential for building a satisfactory apprentice training program.

As a member of foundry management, I do not hesitate to lay the problem on management's own doorstep for the problem cannot be dodged and must be faced honestly and fully. Lip service can be no substitute for action. The issues may be met in every community by working through the local Chamber of Commerce or educational institution. In addition, there must be a desire and intent on the part of management to operate a type of plant which will be both an asset to the industry and an important factor in the economic life of our country.

The apprentice program and its closely related problems all form a challenge to foundry management. Much progress has been made in the past years toward recognition of this fact although, due to economic changes, such a program has been slow. The war has taught us a great deal; now shall we forget many of the lessons it has given us on this important step or will management meet the challenge, take hold and do the job?

E. W. HORLEBEIN, *National Director,*
American Foundrymen's Association

E. W. HORLEBEIN, president, Gibson & Kirk Co., Baltimore, Md., has long been very active in the affairs of A.F.A. and other technical and trade associations. Member of the A.F.A. Brass & Bronze Division and its subcommittees, he was elected as National Director in 1945. Served as first chairman of the Chesapeake chapter and is serving as honorary chairman of that chapter. He also is president, Non-Ferrous Founders Society.

Industrial Progress Will Be Shown at A.F.A. 50th ANNIVERSARY CONVENTION

THE first 100 applications for exhibit space at the Golden Anniversary Foundry Show, to be held in conjunction with the 1946 A.F.A. Foundry Congress at the Cleveland Auditorium May 6-10, clearly indicate that there is greater interest this year than at any show since 1940. It is already evident that "Foundry Week" thus will play a leading role in the postwar sales programs of the equipment and supply companies which serve the foundry industry.

Foundrymen who have attended the A.F.A. exhibits held during the war years will again find the equipment companies staging their traditional interesting and informative demonstrations of more efficient castings production. Many firms who have not exhibited since 1937 and even earlier are applying for space and requesting unusually large accommodations.

In addition, visitors to Cleveland next May will find many new faces among the exhibitors and, according to present indications, many new items of equipment that have not previously been presented at A.F.A. conventions.

Convenient Floor Plan

On accompanying pages A.F.A. presents in miniature the floor plans for the 1946 Foundry Show. Plans and general show requirements have now been mailed to some 2,000 firms whose products and services are sold to the castings industry. From these plans it will be seen that all the exhibits will be on display on the floors below the Registration Lobby, just inside the main Lakeside Avenue entrance to the Auditorium. Thus visitors will be able to take in every display in the entire Show with a minimum of climbing up and down stairs.

Those familiar with the Cleveland Auditorium will recall that the Exhibition Hall and North Hall are on the same level. From North Hall, a visitor enters the Arcade by descending a short stairway, and another short stairway leads from the Arcade into Lakeside Hall, where the heavy operating exhibits will be found. This year, both the upper and lower levels of Lakeside Hall, occupied by Government services during the war years, will be available for the Foundry Show.

Plan Arena Restaurant

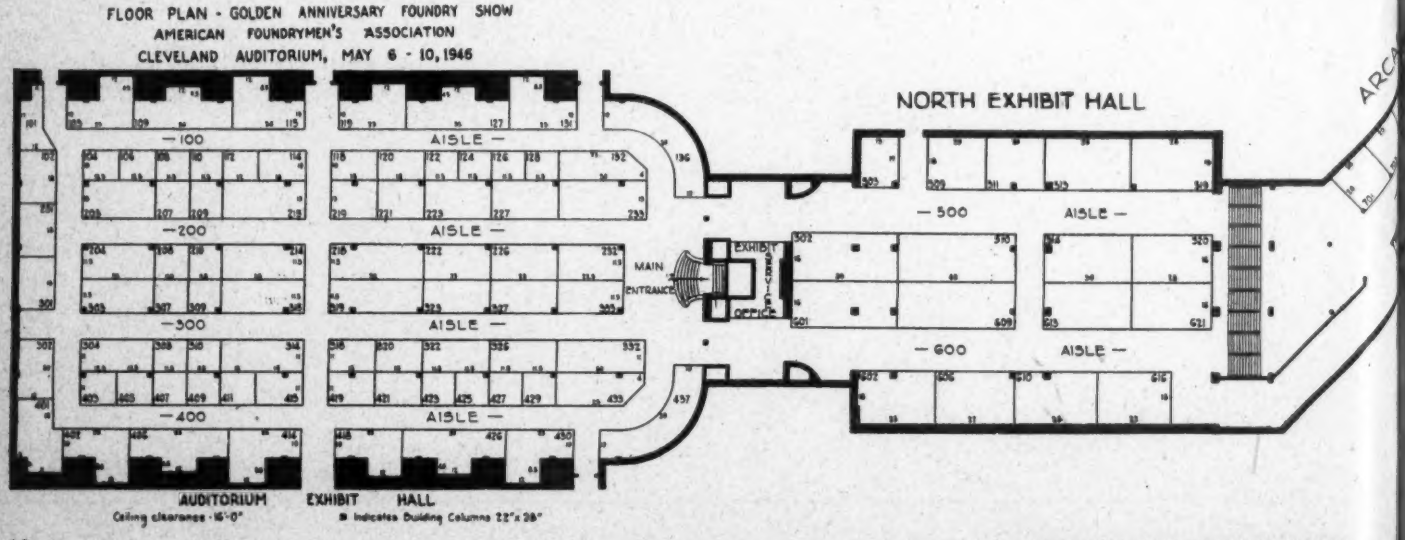
In former years most industrial shows held in the Cleveland Auditorium have utilized the Arena, on the same level as the Main Lobby, for additional exhibits. However, for the 1946 Foundry Show, plans are being made to set up a first-class restaurant and telephone lounge to occupy the entire Arena. Anticipating an overflow crowd, the A.F.A. management believes that the requirements of visitors and exhibitors alike can best be served by thus providing good restaurant facilities in the Auditorium itself.

The Lounge will be fitted out in an attractive style and facilities made available for both local and long distance calls. Many exhibitors have expressed enthusiasm over this plan for a quiet, comfortable and off-to-one-side lounging space such as frequently proves impossible to find on a crowded exhibit floor. They are enthusiastic, too, over the fact that visitors can enter the Auditorium in the morning and, if they so desire, can remain there throughout the entire day, attending the exhibits, and the technical sessions in meeting rooms of the Auditorium.

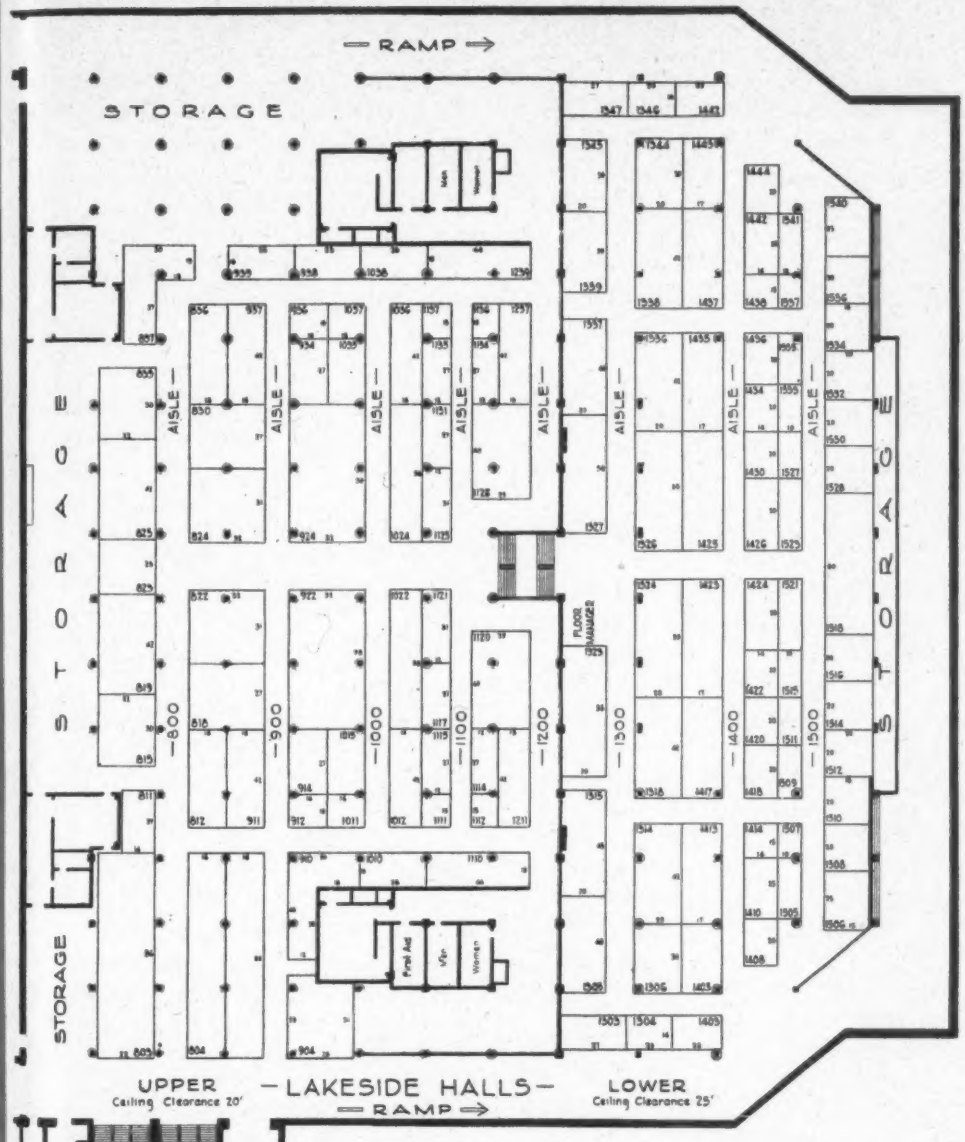
Northeastern Ohio Day

Through cooperation with the Northeastern Ohio Chapter, headed by Chairman A. C. Denison, Fulton Foundry & Machine Co., arrangements are being made to stage a "Northeastern Ohio Day" on Tuesday, May 7. It is planned on this day to have the exhibits open all afternoon and evening for local plant men who might otherwise be unable to attend the show.

As in former years, tickets for Northeastern Ohio Day will be distributed by the host chapter and local firms to plant employees. Plans also are being considered to broaden the admission on this day so as to acquaint more of the general public



• Space applications reveal exhibitors plans for one of most extensive, instructive foundry shows ever staged at an A.F.A. Foundry Congress.



Applications for exhibit space should be mailed promptly to the American Foundrymen's Association, Department of Exhibits, 222 W. Adams St., Chicago 6.

with the fact that the foundry industry is as mechanically and scientifically proficient as any other industry. It has been felt that part of the industry's present manpower difficulties may be traced in part to a lack of information on the part of the general public as to what a foundry is, how it operates, and where its products are used.

Exhibitor Admission

The A.F.A. policy of restricting admission at the Foundry Show to holders of the official Convention badge, obtainable on registration at the Cleveland Auditorium, will again be continued. As in previous years, A.F.A. members are admitted without charge, although non-members are required to pay a small admission fee. Accredited exhibitor representatives will not be required to pay an admission fee at the 1946 Foundry Congress and Show and every effort will be made to simplify, in advance, delays in official registration procedures at Cleveland.

Exhibitor Housing

Frequent requests have been made by exhibitor applicants for hotel accommodations. Official hotel application blanks have now been mailed to all exhibitors of record, as well as to all A.F.A. members, with the request that double and twin bedrooms be requested as much as possible so as to accommodate the largest number of people at the Cleveland Show. Assignments of hotel rooms will commence for all approximately February 15, with preference naturally given to members of the Association and exhibitors at the 1946 Show. Every effort will be made toward an equitable distribution of available rooms, and applications for hotel accommodations should be sent direct to the Official A.F.A. Housing Bureau, 1604 Terminal Tower, Cleveland 13, as soon as possible.

Services necessary to operation of the exhibits are now being contracted for and bulletins will be mailed in due time so that exhibiting firms can indicate their requirements for power, light, furniture, booth equipment, booth signs, telephone service, and the like.

Industry "On Parade"

Included in the first 100 applica-

(Concluded on Page 28)

MICROSTRUCTURE RELATED TO PROPERTIES OF CAST IRON

W. E. Mahin and H. W. Lownie, Jr.,
Materials Engineering Dept., Westinghouse Electric Co.,
East Pittsburgh, Pa.

CAST "iron," the term, actually is a misnomer since this material contains more carbon, as well as other alloying elements, than ordinary steel. Some of the carbon, as in steel, is in combined form. In white cast iron substantially all of the carbon is combined with iron as cementite, and thus "white iron" is similar in microstructure and properties to a very high carbon tool steel.

In gray cast iron, however, usually at least three-fourths of the carbon is in the elemental form; i.e., graphite. Mottled irons consist of mixtures of the structures of white and gray cast iron so that many small areas of each are observable in a fracture surface through such an iron or in the microstructure.

Most of the following discussion is concerned with the microstructure of cast irons which are "gray" when sand-cast in moderately thick or heavy sections.

The microstructure of gray cast iron usually is made up of a matrix similar to that of steel, consisting of all or part of the constituents pearlite, ferrite, and massive cementite and, in addition, containing flakes of graphite. The structure of a typical pearlitic steel is shown in Fig. 1. The similarity of this structure to that of the typical gray cast iron of Fig. 2 is readily apparent.

Nature of Microconstituents

Graphite. Graphite is substantially pure carbon which exists in all gray cast iron in the form of small flakes of irregular shape. When magnified at 100 diameters these flakes appear in the microstructure as dark gray curved lines varying in length from a fraction of an inch to several inches. Thus, their actual length is of the order of a few hundredths of an inch or less. The graphite flakes can be detected in the microstructure in both the unetched and etched conditions.

Graphite is soft and weak and, as will be shown later, has a pronounced effect upon the various properties exhibited by the "steel" matrix. Some of these effects are advantageous, some disadvantageous —depending upon the application.

The dispersion of several per cent of graphitic carbon as flakes in cast iron sometimes results in the erroneous conclusion that cast iron normally is porous. Macro-porosity may occur in gray iron castings just as in any cast metal, but the microstructure of cast iron is inherently sound.

Such soundness is shown in all of the photomicrographs accompanying this discussion as well as in those throughout the literature. The inherent soundness of cast iron is well demonstrated in a recent paper by MacKenzie.[1]

Cast Iron Inherently Sound

Reports of "porous" iron encountered during the polishing of castings such as that shown in Fig. 3 have been investigated repeatedly. If porosity were inherent in the material, such very heavy cast sections would accentuate the effect.

In each case investigated, it was shown that the "porosity" was the result of the tearing out of graphite flakes and the metal surrounding them during machining, or to pitting out during polishing. In each case by adjustment of machining, grinding, and polishing methods the "porosity" was eliminated.

Graphite flakes occur in cast iron in several types of distribution and in a wide range of size. The A.F.A. and A.S.T.M. jointly have prepared a standard chart[2] for the purpose of reporting graphite flake size by number and type of distribution of flakes by letter.

Flake size varies from Size 1 (longest flakes 4 in. or more in

Fig. 1 (Left)—Steel containing partially spheroidized lamellar pearlite. Nital etched, 500X.
Fig. 2 (Right)—Cast iron containing lamellar pearlite, graphite flakes, and a small amount of massive ferrite. Nital etched, 500X.

Fig. 3—Large cast iron thrust bearing runner polished by lapping to a surface finish of about 6 microinches, root mean square.

length at 100 diameters magnification) to Size 8 (longest flakes 1/16 in. or less in length at 100 diameters magnification). Graphite flake distribution varies from Type A (uniform distribution (random orientation) to Type E (interdendritic segregation, preferred orientation).

Cementite. Cementite is iron carbide (Fe_3C), the chemically combined form in which carbon exists in ferrous metals. Part of the total carbon content of cast iron occurs as graphite, the remainder as cementite. The cementite in turn occurs in two forms, (1) as lamellæ with ferrite in pearlite, and (2) as primary or massive cementite. This massive cementite appears in the etched microstructure as irregularly shaped white masses such as those shown in Fig. 9b.

Massive cementite is extremely hard (550 Bhn.) and wear resistant. It is detrimental to machinability even when present in relatively small amounts. The presence of massive cementite is desirable only when wear resistance is of importance.

Occurrence of Ferrite

Ferrite. Ferrite is practically pure iron. It occurs as (1) lamellæ associated with lamellar cementite in pearlite and (2) as free or massive ferrite. Although radically different in properties from cementite, massive ferrite appears somewhat similar to cementite in the etched microstructure, but the two can be differentiated by a slight difference in color and lustre.

Massive ferrite is a microconstituent of low hardness (75 Bhn.), low strength, and high ductility. Its presence is beneficial to machinability (when associated with graphite as in cast iron), but is detrimental to strength and wear resistance.

Pearlite. Pearlite is a laminated microconstituent composed of alternate plates or lamellæ of cementite ferrite. Accordingly, its properties are roughly an average of those two materials. Pearlite is stronger and harder than ferrite but appreciably softer and less brittle than cementite. The appearance of pearlite in the microstructure is shown by etching.

Steadite Effect

Other Microconstituents. Steadite is an iron-carbon-phosphorus eutectic peculiar to cast irons. It is hard and brittle, and its effects are similar to those of cementite. In the normal low-phosphorus irons now being produced for general engineering purposes the small amount of steadite which occurs in small, well-distributed masses is considered to have a rather small effect upon the properties of the iron.

Various other microconstituents such as austenite, bainite, and martensite may be found in cast iron as in steel, but do not occur in ordinary grades of cast iron except when given special heat treatments or specially alloyed.

A thorough treatment of the microconstituents of cast iron and the methods for their examination is presented in an A.F.A. publication by Allen.[3] Reference also may be made to the material and bibliographies pertinent to this subject which are included in the 1944 edition of the CAST METALS HANDBOOK, published by A.F.A.

Effect of Cooling Rate and Composition Upon Microstructure

Figures 4, 5, and 6 illustrate some of the important effects of the cooling rate from the freezing point, and of the composition, upon the microstructure. The changes in microstructure in turn affect the properties of the iron. The effect of cooling rate upon the microstructure and properties of a Class 20 cast iron is shown in Fig. 4.

The variation of cooling rate was obtained by sand casting solid cylinders of increasing diameter. The effect of the same cooling rate conditions upon a Class 40 iron is shown in Fig. 5. Therefore, the difference in microstructure and properties between the Class 20 and Class 40 irons of the same cylinder size is due to the difference in chemical composition.

The cooling rate of the iron shown in Fig. 6 has been controlled by the use of a heavy metal chill. Sections of the test piece close to the chill represent very high cooling rates, whereas sections of the test piece remote from the chill represent much lower rates.

The cooling rate of cast iron in a sand mold is determined primarily by the section size of the casting and the presence or absence of chills. The effects upon the microstructure of increasing cooling rate are:

1. Increase the tendency to form massive cementite and thus decrease the amount of carbon present as graphite.
2. Increase the fineness of pearlite (i.e., decrease the spacing of the lamellæ).
3. Decrease the size and change the distribution of graphite flakes.
4. Decrease the tendency to form massive ferrite. An exception to this is at certain high cooling rates where interdendritic graphite occurs. Ferrite tends to be associated with this type of graphite, as shown in Fig. 7.

Similar changes in microstructure

• Cast iron microstructures and attendant properties may be changed by quenching and tempering treatments to improve strength and hardness. Alloying elements may be used to develop microstructures of increased strength, hardness, greater wear resistance.

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Gray Iron Division of A.F.A.

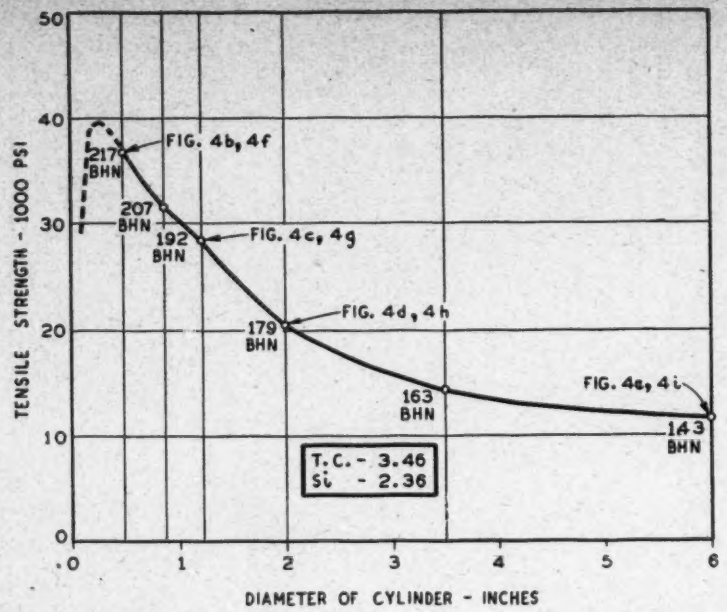


Fig. 4a—The effect of microstructure upon the tensile strength and hardness of a Class 20 cast iron. Test specimens were taken from sand cast cylinders of the indicated diameters.

Fig. 4b—Graphite distribution of Class 20 cast iron from ½-in. cylinder. Fine interdendritic graphite of rating 6E, 7D. Unetched, 100X.

Fig. 4c—Graphite distribution of Class 20 cast iron from 1.2-in. cylinder. Small random graphite flakes of rating 5A. Unetched, 100X.

Fig. 4d—Graphite distribution of Class 20 cast iron from 2-in. cylinder. Moderately sized random graphite flakes of rating 4A. Unetched, 100X.

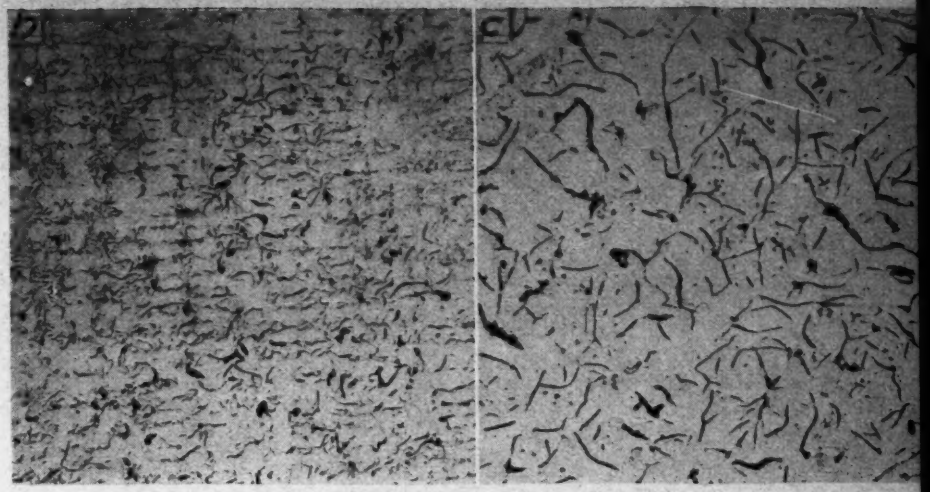
Fig. 4e—Graphite distribution of Class 20 cast iron from 6-in. cylinder. Very coarse random graphite flakes of rating 1A. Longest flakes are more than 4 in. in length at 100X. Unetched, 100X.

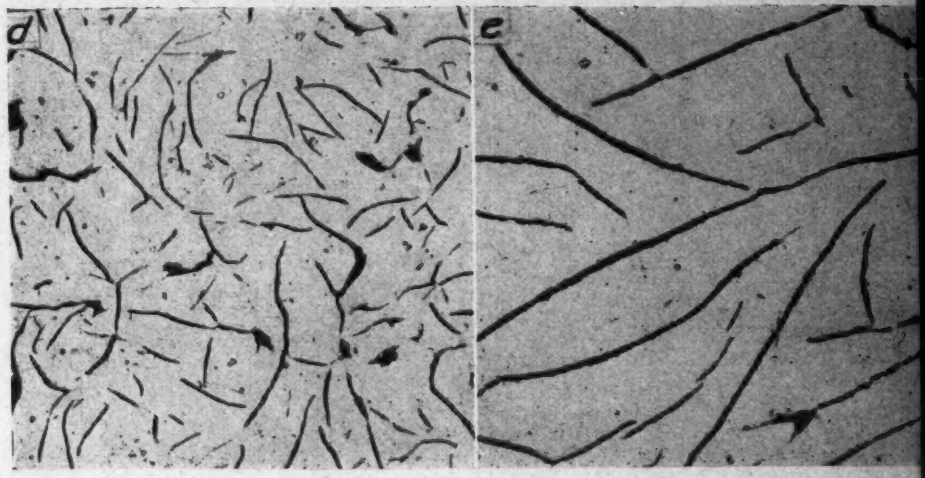
Fig. 4f—Microstructure of Class 20 cast iron from ½-in. cylinder. Specimen contains moderately fine pearlite and interdendritic graphite. Picral etched, 1000X.

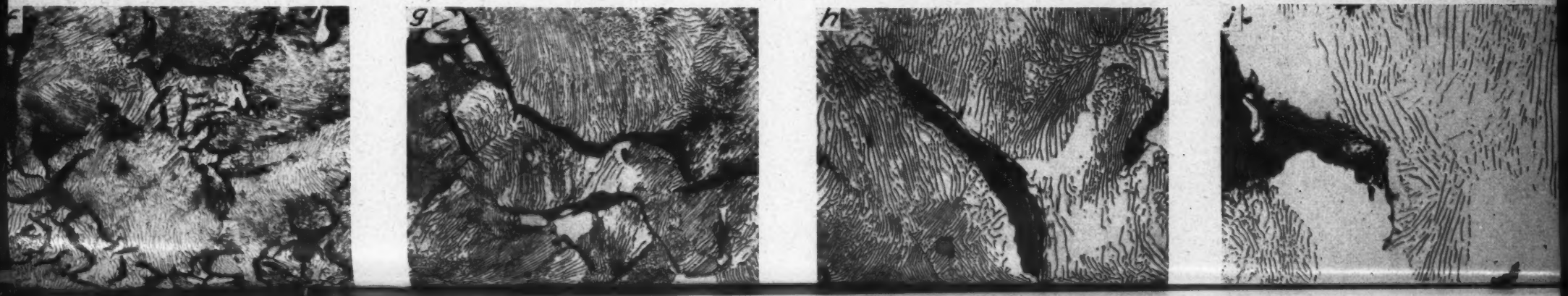
Fig. 4g—Microstructure of Class 20 cast iron from 1.2-in. cylinder. Pearlite is slightly coarser than in Fig. 4f and a small amount of massive ferrite has formed. Picral etched, 1000X.

Fig. 4h—Microstructure of Class 20 cast iron from 2-in. cylinder. Specimen contains coarse pearlite and massive ferrite. Picral etched, 1000X.

Fig. 4i—Microstructure of Class 20 cast iron from 6-in. cylinder. The microstructure is composed of very coarse pearlite and a large amount of massive ferrite. Picral etched, 1000X.







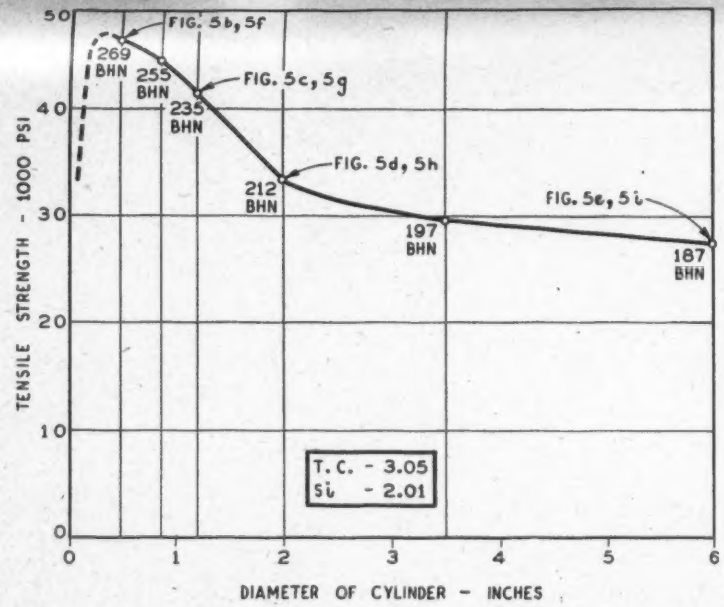


Fig. 5a—The effect of microstructure upon the tensile strength and hardness of a Class 40 cast iron. Test specimens were taken from sand-cast cylinders of the indicated diameters.

Fig. 5b—Graphite distribution of Class 40 cast iron from ½-in. cylinder. Fine graphite flakes of rating 6E, 7D. Unetched, 100X.

Fig. 5c—Graphite distribution of Class 40 cast iron from 1.2-in. cylinder. Distribution of mixed types and sizes of flakes (5A and 6E). Unetched, 100X.

Fig. 5d—Graphite distribution of Class 40 cast iron from 2-in. cylinder. Size 4, Type A random graphite flakes. Unetched, 100X.

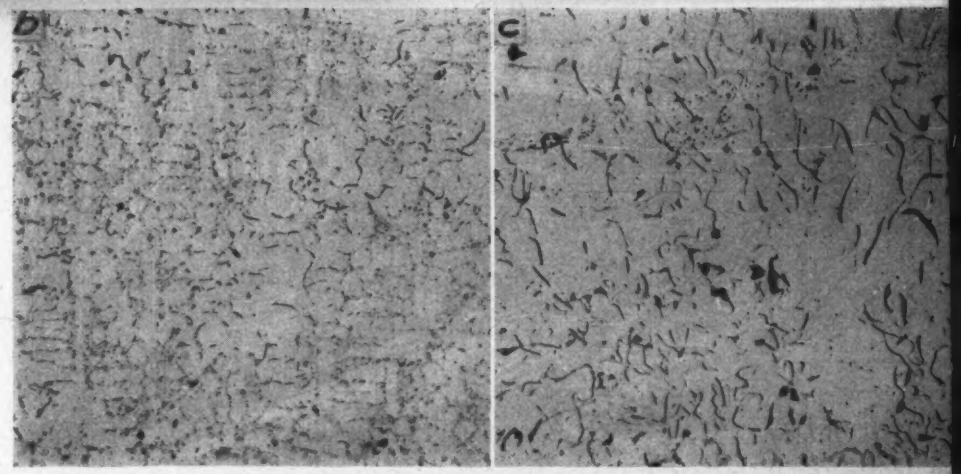
Fig. 5e—Graphite distribution of Class 40 cast iron from 6-in. cylinder. Size 3 random flakes. Note the small size of these flakes as compared to the large flakes found in the Class 20 iron in a 6-in. cylinder (Fig. 4e). Unetched, 100X.

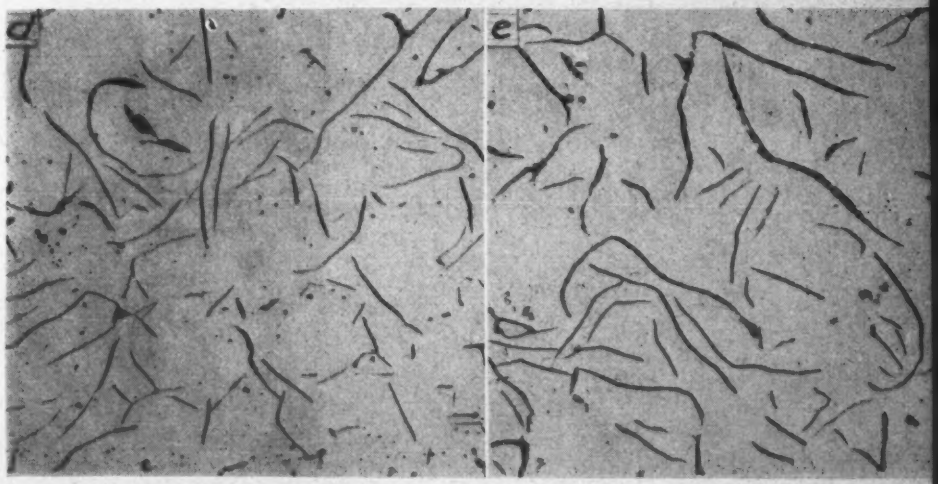
Fig. 5f—Microstructure of Class 40 cast iron from ½-in. cylinder. Matrix is composed of fine pearlite and a small amount of massive cementite. Picral etched, 1000X.

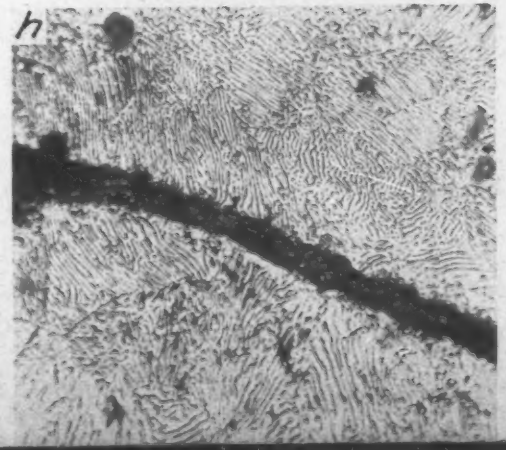
Fig. 5g—Microstructure of Class 40 cast iron from 1.2-in. cylinder. Moderately fine pearlite and traces of massive cementite. Picral etched, 1000X.

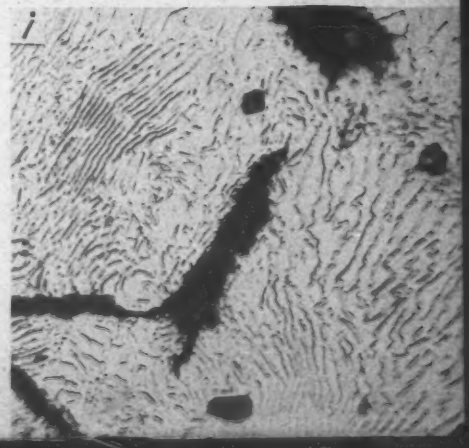
Fig. 5h—Microstructure of Class 40 cast iron from 2-in. cylinder. Matrix is composed entirely of moderately coarse pearlite. Picral etched, 1000X.

Fig. 5i—Microstructure of Class 40 cast iron from 6-in. cylinder. Matrix consists of coarse pearlite. Note absence of massive ferrite as compared to Fig. 4i. Picral etched, 1000X.









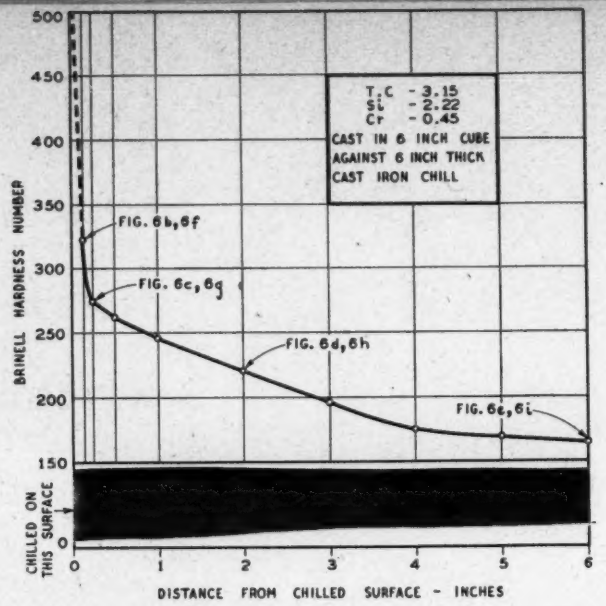

T.C - 3.15
Si - 2.22
Cr - 0.45
CAST IN 6 INCH CUBE AGAINST 6 INCH THICK CAST IRON CHILL
FIG. 6b, 6f
FIG. 6c, 6g
FIG. 6d, 6h
FIG. 6e, 6i
BRINELL HARDNESS NUMBER
CHILLED ON THIS SURFACE
DISTANCE FROM CHILLED SURFACE - INCHES

Fig. 6a—The effect of cooling rate upon the microstructure and hardness of a low alloy cast iron. The photograph illustrates the fracture appearance of a section cut from the center of the 6-in. cube. The white fracture next to the chilled surface is due to the formation of massive cementite. The coarsening of the fracture surface is due to the increase of graphite flake size as distance from chill increases.

Fig. 6b—Graphite distribution in alloyed cast iron 1/8-in. from chill. Fine interdendritic graphite; Rating 6E, 8D. Unetched, 100X.

Fig. 6c—Graphite distribution in alloyed cast iron 1/4-in. from chill. Small random flakes; Type A, Size 5. Unetched, 100X.

Fig. 6d—Graphite distribution in alloyed cast iron 2 in. from chill. Random graphite flakes; Type A, Size 4. Unetched, 100X.

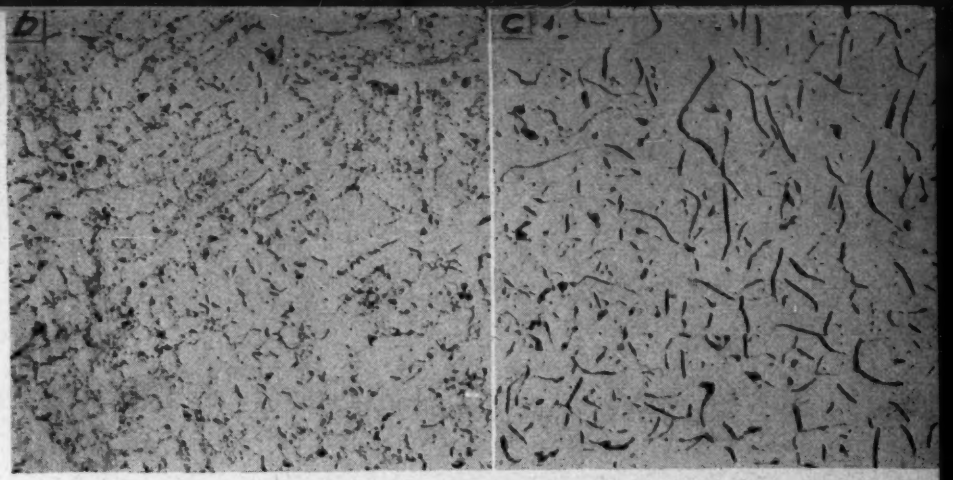
Fig. 6e—Graphite distribution in alloyed cast iron 6 in. from chill. Coarse random flakes; Type A, Size 3. Unetched, 100X.

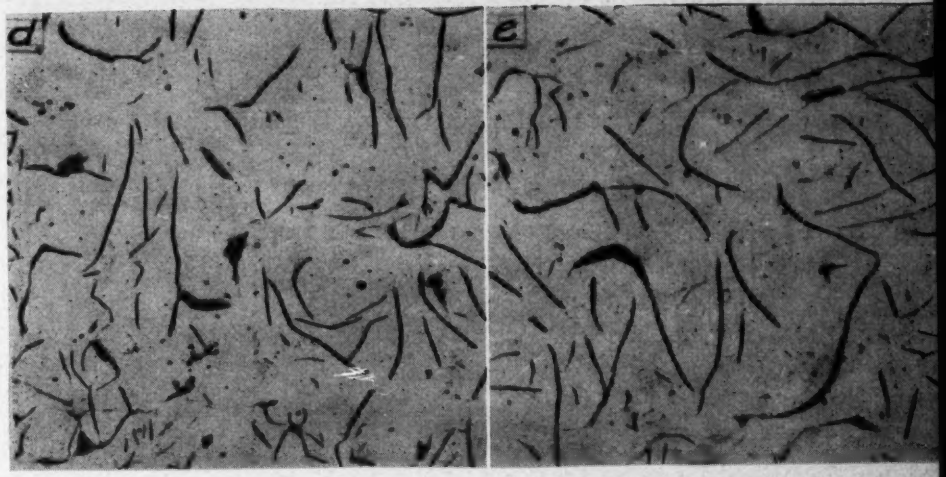
Fig. 6f—Alloyed cast iron 1/8-in. from chill. The microstructure consists of moderately fine pearlite and a considerable amount of massive cementite. Nital etched, 500X.

Fig. 6g—Alloyed cast iron 1/4-in. from chill. The microstructure consists of moderately fine pearlite and a small amount of massive cementite. Nital etched, 500X.

Fig. 6h—Alloyed cast iron 2 in. from chill. The microstructure consists of moderately fine pearlite and traces of massive ferrite. Nital etched, 500X.

Fig. 6i—Alloyed cast iron 6 in. from chill. The matrix contains moderately coarse pearlite and considerable massive ferrite. Nital etched, 500X.





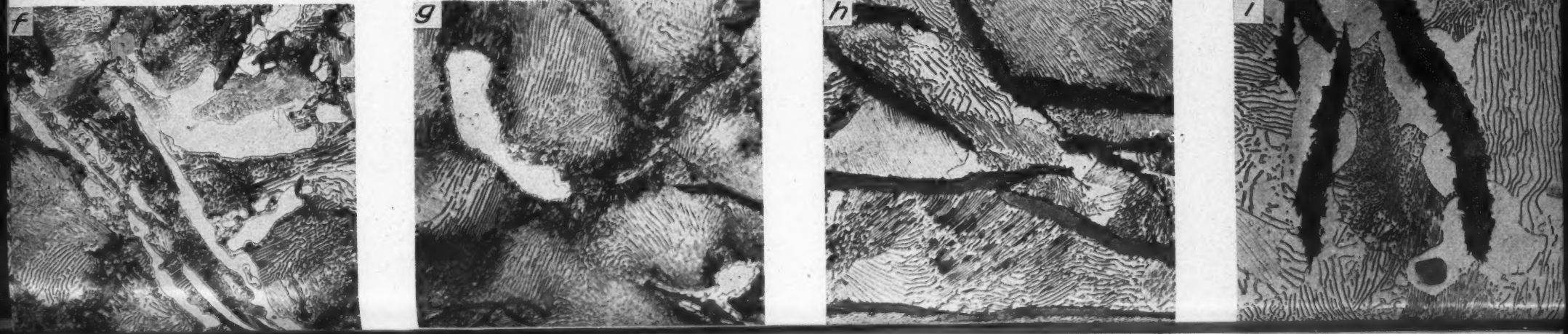


Fig. 7—Massive ferrite as associated with fine interdendritic (Type D) graphite flakes. Gray background is unresolved pearlite. Picral etched, 500X.

can be produced by changes in composition. Increasing the total carbon and silicon contents acts in the same direction as decreasing the cooling rate. Decreasing total carbon and silicon contents or increasing contents of stabilizing alloys such as chromium and molybdenum act similarly to increasing the cooling rate. This composition factor is illustrated by a comparison of Figs. 4 and 5.

Microstructure—Properties

Effect of Graphite. Considering the matrix of cast iron as quite similar to that of steel, the effects of the graphite flakes upon the matrix properties are shown graphically in Fig. 8 and summarized as follows:

1. Reduce tensile strength, yield strength, and per cent elongation (ductility) due to interruption of the continuity of the matrix.

2. Exert little effect upon Brinell hardness. However, the hardness of a cast iron may be higher than that of a steel of similar combined carbon content due to the effect of solid solution elements such as silicon and phosphorus in strengthening the matrix.

3. Reduce the modulus of elasticity, specific gravity, thermal conductivity, thermal expansion, specific heat, and electrical conductivity.

4. Increase damping capacity because of the cushioning effect of the soft flakes.

5. Reduce notch sensitivity (increase the ratio of fatigue strength to tensile strength in notched bars) due to the stress distribution effect of the dispersed flakes.

6. Improve machinability because of lubricating action and the brittleness of the chip.

7. Decrease galling in bearing applications, again because of the lubricating effect imparted by the graphite flakes.

The amount, size, and distribution of the graphite flakes materially affect the properties of cast iron. However, due to the fact that the same factors that affect the graphite also affect the matrix, it is difficult to evaluate quantitatively the individual effects of the variations of the graphite.

If it were practical to develop various distributions and sizes of graphite flakes in a constant matrix, then it would be possible to evaluate the effect of various graphite dispersions. In the case of malleable iron, where the matrix is entirely ferritic, it has been possible to make such a correlation of the effect of primary graphite flakes upon physical properties.[4]

Therefore, the changes of properties with microstructure (as shown in Figs. 4, 5, and 6) are the result of combined changes of the graphite flakes and of the matrix. An attempt to determine semi-quantitatively the effects of microstructure upon properties has been reported recently by Adams.[5]

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

Adams considered as variables of microstructure: (1) graphite characteristics, (2) matrix structure, and (3) cell size. The cells studied by Adams are apparently the result of the segregation of lower melting point constituents to austenite grain boundaries.

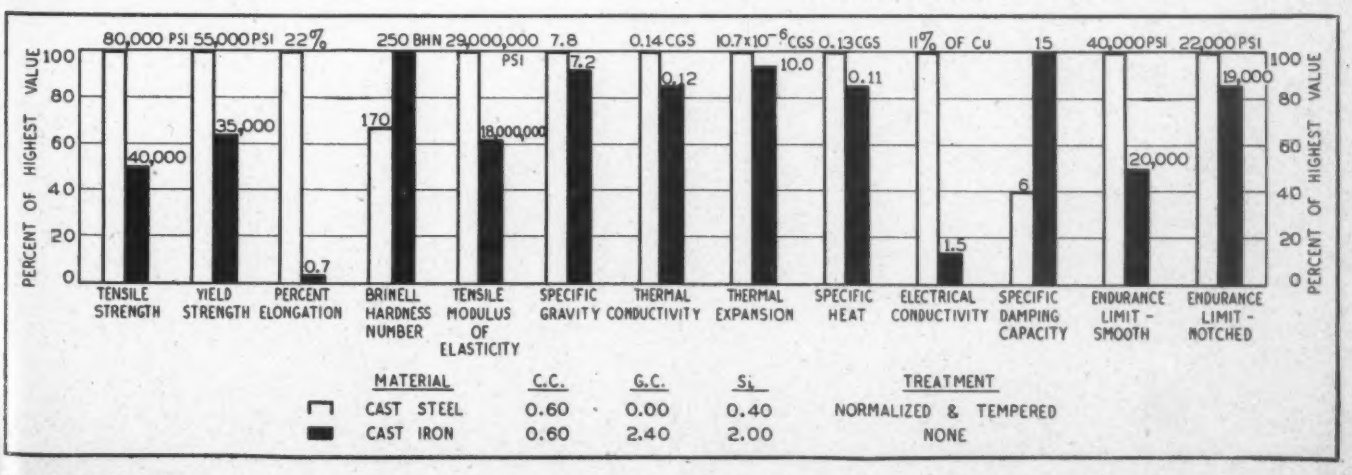
Although the quantitative effects of changes in the microstructure of graphite on properties have not yet been determined, certain qualitative effects listed below are known:

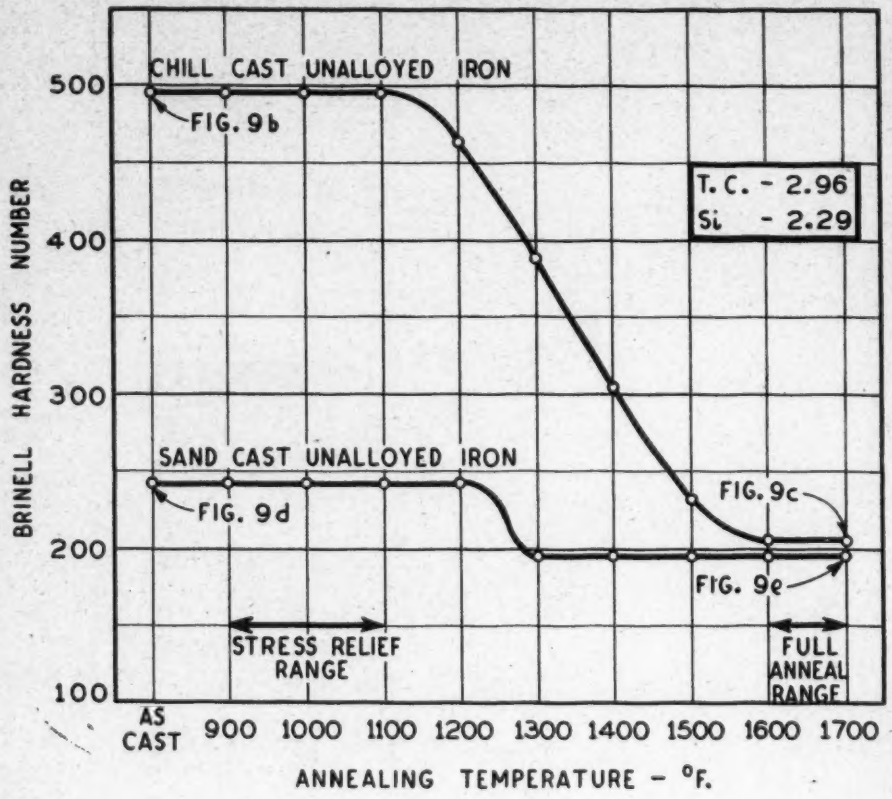
1. Increased amounts of graphitic carbon reduce strength and increase machinability.

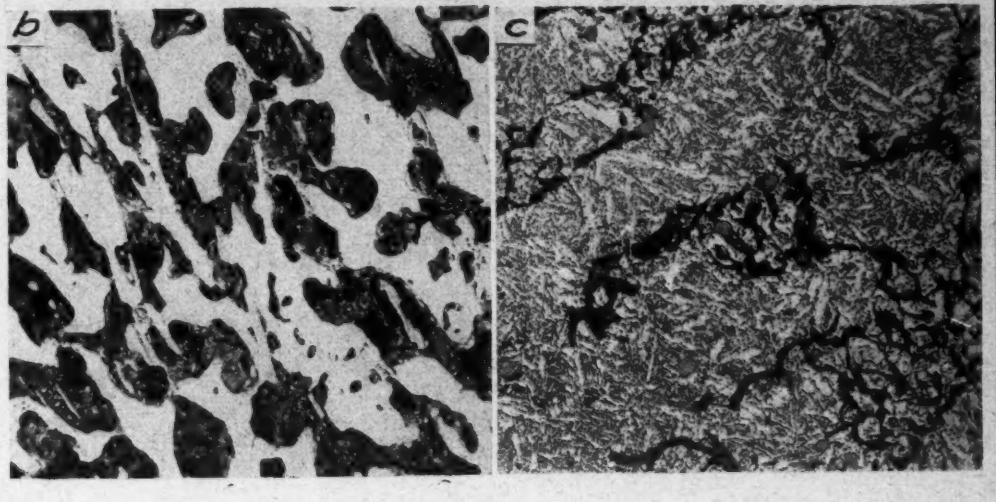
2. Graphite flake distribution and size have little effect upon hardness which is controlled primarily by the structure of the matrix. Hardness is a function of composition and cooling rate, both of which affect the structure of the matrix and control the presence of massive cementite.

3. Small random (Type A) graphite flakes are conducive to higher tensile strengths than are small in-

Fig. 8—Schematic comparison of the properties of cast iron and cast steel both having the same combined carbon content. The principal difference in microstructure is the presence of graphite flakes in the cast iron. A small part of the difference in most properties can be attributed to the difference in silicon content.







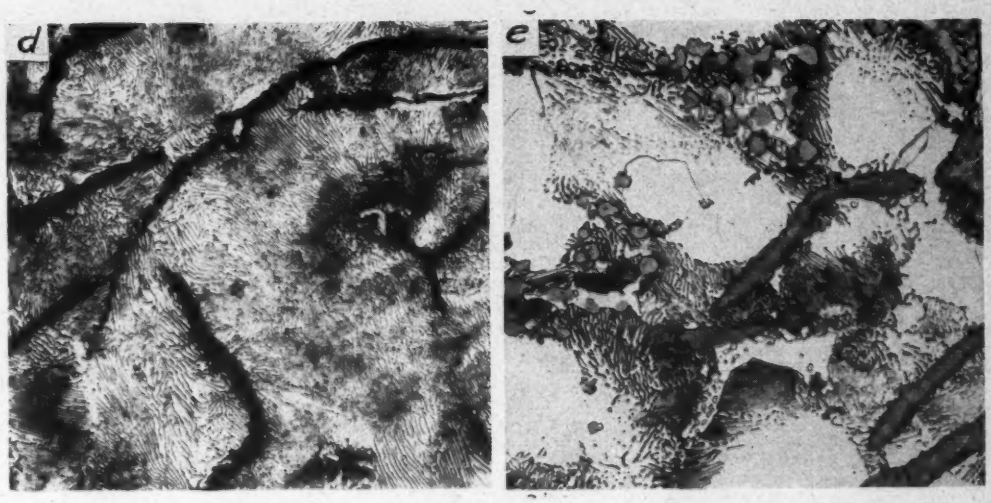


Fig. 9a—The effect of annealing upon the microstructure and properties of unalloyed cast irons. All samples were cast in 1.2-in. diameter bars, held at temperature one hour, and furnace cooled.

Fig. 9b—Chill cast unalloyed iron consisting of large masses of massive cementite in a background of fine unresolved pearlite. Nital etched, 500X.

Fig. 9c—Same iron as Fig. 9b after annealing at 1700° F. The microstructure consists of graphite flakes in a matrix of fine spheroidized pearlite. Nital etched, 500X.

Fig. 9d—Sand cast unalloyed iron consisting of fine pearlite and large graphite flakes. Nital etched, 500X.

Fig. 9e—Same iron as Fig. 9d after annealing at 1700° F. The microstructure consists of coarse graphite flakes in a matrix of massive ferrite and partially spheroidized pearlite. Nital etched, 500X.

terdendritic groupings or large random flakes. This effect cannot be seen from the curves accompanying this article as the weakening effect of the small interdendritic flakes (Types D and E) obtained by rapid cooling is overbalanced by the effect of faster cooling in strengthening the matrix.

Ladle inoculation is proposed widely throughout the literature as a means of improving strength by reducing the tendency for formation of interdendritic graphite. The theory and effects of ladle inoculation have been summarized in a recent paper.[6]

Massive Cementite Effect. Massive cementite is to be avoided when an iron is to be machined. Although a uniform distribution of cementite particles throughout a matrix may have little effect upon hardness and cause only a small reduction in tensile strength, it may cause an iron to be virtually unmachinable by ordinary methods, or in milder cases to force reduced machining speeds and feeds. Conversely, massive cementite is desirable when wear resistance is the primary service requirement.

Pearlite Effect. As in steel, fine pearlite is conducive to relatively high strength and hardness; coarse pearlite to lower strength and hardness. Even very coarse pearlite, however, is considerably stronger than massive ferrite. All massive cementite-free, pearlitic cast irons are readily machinable. Irons containing coarse pearlite machine somewhat more readily than those containing fine pearlite.

Massive Ferrite Effect. Massive ferrite in cast iron has the same effects as in steel. It is a soft and weak constituent that is readily machinable, especially so in cast iron where the chips break up readily due to the effect of the graphite flakes.

Effect of Heat Treatment Upon Microstructure and Properties

Annealing Effect. Annealing below the critical range (for example, at 1000-1150° F.) has practically no effect upon the microstructure and hence little effect upon physical properties, but may be used to relieve stresses and reduce or eliminate distortion of finished parts.

Full annealing changes the microstructure considerably. Such a heat treatment above the critical range (for example, at 1500-1750° F.) breaks up massive cementite to form graphite and ferrite, thereby increasing machinability. Full annealing, consisting of slow cooling following heating at the annealing temperature, also will soften the pearlitic matrix, especially in castings having relatively thin sections or in chill-cast or permanent mold castings.

Therefore, such treatment will result in a considerable reduction in hardness and strength, but will increase machinability. Figure 9 illustrates the structural changes occurring during the annealing of two typical cast irons at various temperatures.

Quenching and Tempering Effect. Due to the similarity of the cast iron matrix to steel, the structure and properties of cast iron can be changed, as for steel, by quenching and tempering. The limitation imposed by the low ductility of cast iron is that complicated sections sometimes cannot be quenched because of the tendency to form quenching cracks.

Martensitic Matrix

Figure 10 shows the martensitic matrix developed by oil quenching and tempering of the iron shown in Fig. 2. By thus changing the microstructure, the tensile strength was increased from 36,000 to 53,000 psi. In a typical case, quenching was used to increase the hardness of a cast iron from 200 to 500 Bhn. Wear resistance in such cases increases greatly over that of the as-cast structure.

A high initial combined carbon is not necessary for the hardening of a cast iron by quenching as relatively rapid re-solution of carbon from the graphite flakes occurs at temperatures above the critical range. Irons composed entirely of graphite and ferrite may be hardened to high hardness by suitable treatment.

Acicular Structures. Flinn and Reese[7] have shown that suitable alloying of cast iron with nickel and molybdenum, followed by a low temperature heat treatment, will result in acicular structures such as that shown in Fig. 11. Such irons are reported to have tensile strengths up to 105,000 psi.

Summary

The effects of microstructure upon the tensile strength and hardness of cast iron can now be summarized by a closer study of Figs. 4, 5, 6, and 9.

In Figs. 4, 5, and 6, as the section size increases, massive cementite disappears, the pearlite becomes coarser, graphite flakes become larger and free ferrite appears in greater quantities. Each of these changes contributes to the progressive lowering of the tensile strength and to improved machinability.

However, with thin sections or the use of chills, a condition is reached where massive cementite begins to form. As the amount of massive cementite increases, tensile strength and machinability drop rapidly,

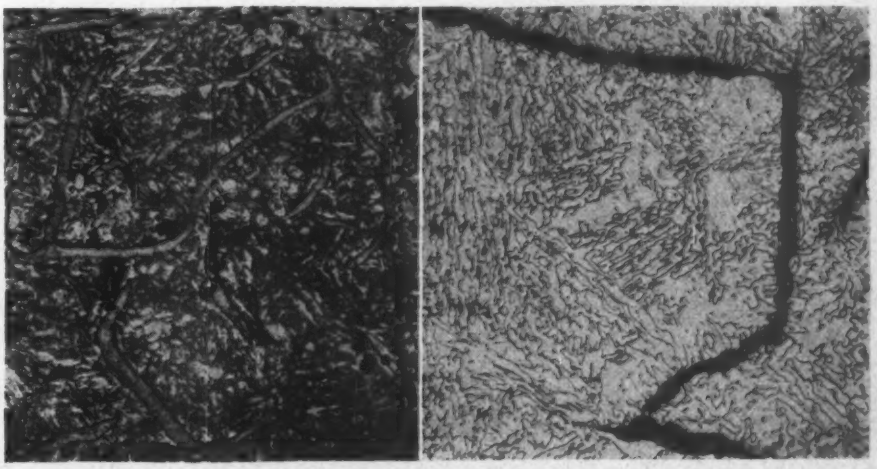


Fig. 10 (Left)—Same iron as that shown in Fig. 2 after oil-quenching from 1500° F. and tempering at 900° F. The microstructure consists of graphite flakes in a matrix of tempered martensite. Nital etched, 500X. Fig. 11 (Right)—Acicular structure formed by certain nickel-molybdenum alloy iron compositions. When tempered at low temperatures this type of microstructure is responsible for very high tensile strengths of the order of 60,000 to 100,000 psi. Nital etched, 500X.

whereas hardness increases. This formation of massive cementite, therefore, is responsible for the sudden drop in tensile strength occurring for the thin sections illustrated in Figs. 4 and 5.

Lowering of the total carbon and silicon contents of the metal decreases the graphitizing tendency of the iron and increases the stability of the cementite (including the cementite in the pearlite). Such a change in analysis, therefore, tends to restrict coarse pearlite, large graphite flakes, and the formation of massive ferrite, and hence results in higher tensile strength and hardness, especially in the thicker sections. A comparison of Figs. 4 and 5 shows this to be true.

Full Annealing

Figure 9 illustrates the fact that full annealing of a cast iron is to be avoided when high hardness and high strength are desired. Full annealing will eliminate massive cementite, however, and will promote the presence of ferrite, so that machinability is increased.

Stress relief annealing results in substantially no change in microstructure and does not adversely affect tensile strength or hardness. Therefore, such treatment generally will be beneficial to any engineering application, especially so in the case of large castings or those with complex combinations of thin and thick sections.

As in the case of steel, the microstructure and attendant properties of cast iron may be changed by the use of quenching and tempering treatments and by the utilization of alloying elements. Quenching and tempering result in improved strength and hardness through formation of martensite, bainite, etc., in the "steel" matrix.

Similarly, alloying elements may be used to develop microstructures of increased strength and hardness and improved wear resistance. Some of the alloying effects may be attributed to the control of graphitization; others may be caused by effects on the matrix.

Considered from the standpoint of casting design, a cast iron for a given application should be selected with consideration to the microconstituents which make up the iron. Section thicknesses should be uniform, or a variation in properties in the different parts of a casting will be obtained.

If machinability and strength are desired in light sections, the type of iron used is especially important. Very light sections must be carefully considered in the metallurgy of the iron used in order to prevent occurrence of massive cementite and resultant difficulties with machining. Annealing will help but leads to low strength. If strength is desired in heavy sections, the analysis of the iron must be selected to give the desired properties.

Because of the variation in microstructure with cooling rate, it is important to notice that a tensile strength determination on a test bar does not indicate the strength of the iron in all sections of a casting. A test bar tensile strength corresponds only to the tensile strength of similar section thicknesses in the casting; sections in the casting that are heavier than the test bar will have lower strength and lower hardness than the test bar because of the effect of microstructure as noted previously.

Likewise, a test bar tested in the as-cast condition will be of little value in estimating the strength or hardness of a casting that subsequently has been given a full anneal, even though the test bar is of a section thickness similar to that of the casting.

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5. R. R. Adams, "Cast Iron Strength vs. Structure," TRANSACTIONS, American Foundrymen's Association, vol. 50, pp. 1063-1103 (1942).
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7. R. A. Flinn and D. J. Reese, "The Development and Control of Engineering Gray Cast Irons," TRANSACTIONS, American Foundrymen's Association, vol. 49, pp. 559-607 (1941).

British Exchange Paper Relates Bomb Production

FROM the Institute of British Foundrymen word has been received that Basil Gray, special director, English Steel Corporation, Ltd., Sheffield, England, is to prepare the annual exchange paper to be presented on behalf of the British foundrymen at the 1946 A.F.A. convention. Mr. Gray's paper will deal with the production of the "tall-boy" and "grand-slam" aerial bombs, and will describe a technique of interest to the American foundrymen, as certain details will be released that are not common with the U. S. practice. This paper will be one of the highlights of the 50th Anniversary Gonvention meeting to be held in Cleveland May 6-10.

Fiftieth Anniversary Exhibit

(Continued from Page 19)

tions for space are firms manufacturing and selling to the foundry industry such products as molding machines, melting furnaces, pattern shop equipment, laboratory equipment, core oils, non-ferrous ingots, refractories, shakeout equipment, material handling equipment, dust control equipment, sand conditioning equipment, electrical and pneumatic tools, cleaning room equipment, abrasives, safety equipment, crucibles, coal and coke, flasks, x-ray equipment, industrial trucks, compressors, graphite products, foundry supplies, sand products, and consulting engineering services.

Important Event

It has been said that the 50th Anniversary Foundry Congress and Foundry Show may well prove to be the most important event of its kind ever staged by A.F.A. by and for the castings industry. Problems of reconversion, manpower, more efficient production, lower costs, and quality consistent with that demanded of castings throughout the war years, undoubtedly will attract thousands of progressive foundry operators.

Applications for exhibit space should be mailed promptly to the American Foundrymen's Association, Department of Exhibits, 222 W. Adams St., Chicago 6.

TECHNICAL PROGRAM for GOLDEN ANNIVERSARY

Convention Begins to Take Form

• Division Program and Papers Committees and General Interest Committees are working hard to make the technical sessions of the 50th Anniversary Convention outstanding in the history of A.F.A. New techniques and processes to be discussed.

THE technical program for the 50th Anniversary A.F.A. Convention to be held in Cleveland, May 6-10, is in the process of formation. While the tentative schedule of sessions is not yet available, the general program indicates that in the neighborhood of 50 sessions will be held on various phases of foundry science and practice. Foundrymen who will attend from all sections of the country will find within the various technical sessions much information of value to them in their every day production problems. The sessions will definitely carry out the objectives of the Association, namely, "to promote the arts and science applicable to metal casting manufacture, and to improve the methods of production and the quality of castings."

The growth of membership in the Association during the past several years, an increase in the number of chapters, plus the fact that no annual convention was held last year, foretells great interest in technical sessions of the 50th Anniversary Convention. Many members of the Association are familiar with the excellent facilities of the Cleveland Auditorium for staging technical meetings and their close proximity to meeting rooms to this exhibit which makes large attendance at such sessions a foregone conclusion.

General Plans

Sessions will be arranged so that specific interest groups will stage their meetings on successive days. Management and general interest sessions will be held at opportune times throughout the week. Because of the large number of sessions scheduled, it will be necessary to continue the practice of holding some sessions during the evening.

In addition to the formal sessions, numerous committee meetings are being planned. It is anticipated that the number of such meetings will be quite large, due to the fact that many committees have become increasingly active since the wars end and others have not held meetings of any type for as long as two years.

Technical Sessions

Sessions of specific interest will be held by the Brass and Bronze, Aluminum, Steel, Gray Iron, Malleable and Pattern Making Divisions of the Association.

Gray Iron

The Gray Iron Division is planning five sessions, two of which will be devoted to a "Symposium on Engineering Properties," which is being staged by a sub-committee of the Gray Iron Division, Program and Papers Committee. It is intended to extend to the Materials Engineering Division, American Society of Mechanical Engineers, an invitation to attend these sessions.

Another session to be staged by the Gray Iron Division will be on "Welding of Gray Iron," covering welding fundamentals, arc-welding, gas welding and welding testing. In addition, two sessions on general topics of interest to gray iron foundrymen are scheduled. Papers at these two sessions will deal with slag control, cupola melting, the theory of inoculation, and the effect of heat treatment on the endurance limit of cast iron.

One of the features of a general interest session will be a detailed explanation of the operation charts shown in the CUPOLA OPERATIONS HANDBOOK, and a paper dealing with the relation between tensile strength and hardness of cast iron. The Gray Iron Shop Operation Course will be continued, as in the past, and will be composed of four sessions, two of which will be devoted to the causes of casting defects attributed to metal. These two sessions will be under the guidance of the Gray Iron Division Committee on Analysis of Casting Defects. The other two sessions will be devoted to the metallurgy of cupola mixtures and carbon control, rather important and timely topics.

Brass and Bronze

The Brass and Bronze Division is planning on at least two sessions in which it is hoped to cover such subjects as new methods for casting straight copper castings, and new techniques facilitating the removal of gates and risers. It is also hoped to secure a report of the Brass and Bronze Division Committee Advisory to the Army Ordnance Department, and a paper on methods of increasing yield of brass and bronze castings by reduction of riser size. In addition the feature of Brass and Bronze Division programs during the past conventions, namely, the Annual Round Table Conference, will be held. The subject of this session, however, has not as yet been determined.

Malleable Iron

Continuing the policy of the past several years, the Malleable Division will hold a symposium on the subject of "Coremaking." This symposium will follow those in the past, on graphitization, melting, gating and risering, and sand practice. Other papers in the offing include one which compares the processing of malleable iron using various types of annealing equipment, the practical aspects of air-furnace melting with emphasis on charging procedure, and the effect of boron on malleable iron.

Pattern Making

The Pattern Making Division plans to have several papers, one dealing with "Patterns as the Jobbing Foundry Sees Them," and a companion paper discussing the same problem from the standpoint of production foundries. It is also proposed that the Division will discuss

(Concluded on Page 37)

PATTERN and Allied EQUIPMENT

Design, Redesign and Interchangeability

By William E. Tharp, Foundry Technical Supervisor,
Caterpillar Tractor Co., Peoria, Ill.

• Designing engineers are weighing the advantages and disadvantages of foundry products as compared with the products of competitive processes. Lower cost per unit is the foundry's greatest asset. To maintain this cost advantage in the face of improved methods in other processes, the foundry must develop methods to produce castings at lower costs and to closer tolerances. Close cooperation between the casting designer and the foundryman, to obtain greater casting accuracy and lower costs through correctly designed patterns and the use of interchangeable pattern and other equipment, is a factor for the foundryman's careful consideration.

IT WAS NOT until centuries after the discovery of enduring metals, and the forming of parts therefrom, that the pouring of molten metal into a sand or clay mold was successfully accomplished.

The first parts to be made from metals were not poured. They were hammered into shape from a semi-molten mass of metal. This method of producing metal parts, with a few exceptions in bronze, existed for centuries.

It was not until the eighteenth century that man conceived and mastered the art of casting molten metal into a sand mold. Due to the demand for duplicate parts, he found that a pattern would be necessary. This pattern was made by the early foundryman himself, who must necessarily have been a smith or a metals craftsman.

The only reason for relating this thumb-nail history of castings and patterns is to impress upon the reader that patterns, in their infancy, were designed and, in most cases, made by the foundryman himself.

In later years, because of an increased demand for castings, it became necessary for the foundryman to hire craftsmen, who worked chiefly with wood, to make patterns for him. Even then the foundryman had to advise the craftsman in matters of moldability, but as the years passed the foundryman gained more and more confidence in his hireling and relinquished the greater part of the responsibility for the design of the pattern to the now titled pattern-maker. The results of this shift in responsibility are obvious in most, and possibly all, foundries today.

The fact that many patterns are poorly designed and are, therefore, responsible for a greater cost per casting, or a greater scrap percentage than should be necessary, should be a warning that the responsibility for the design of all patterns not only should be assumed but exercised by the foundryman.

A close follow-up with the pattern-maker should necessarily be maintained in order that small but harassing details, such as correct flask size, proper draft, correct partings of patterns and core boxes, correct placement of patterns in flask for proper gating, venting and wiring of cores, sturdy core driers, etc., are cared for in advance.

To say that correct pattern design is an art would be an understatement. It is both an art and an engineering achievement. A pattern, whether large or small, of wood or metal, can be designed in many different ways, and a casting derived from each could check just as dimensionally accurate from one as from another. Yet one design would stand out in the critical eyes of the foundryman as being most adaptable to his individual conditions.

Good proof of the foregoing statement is found in the entries by ap-

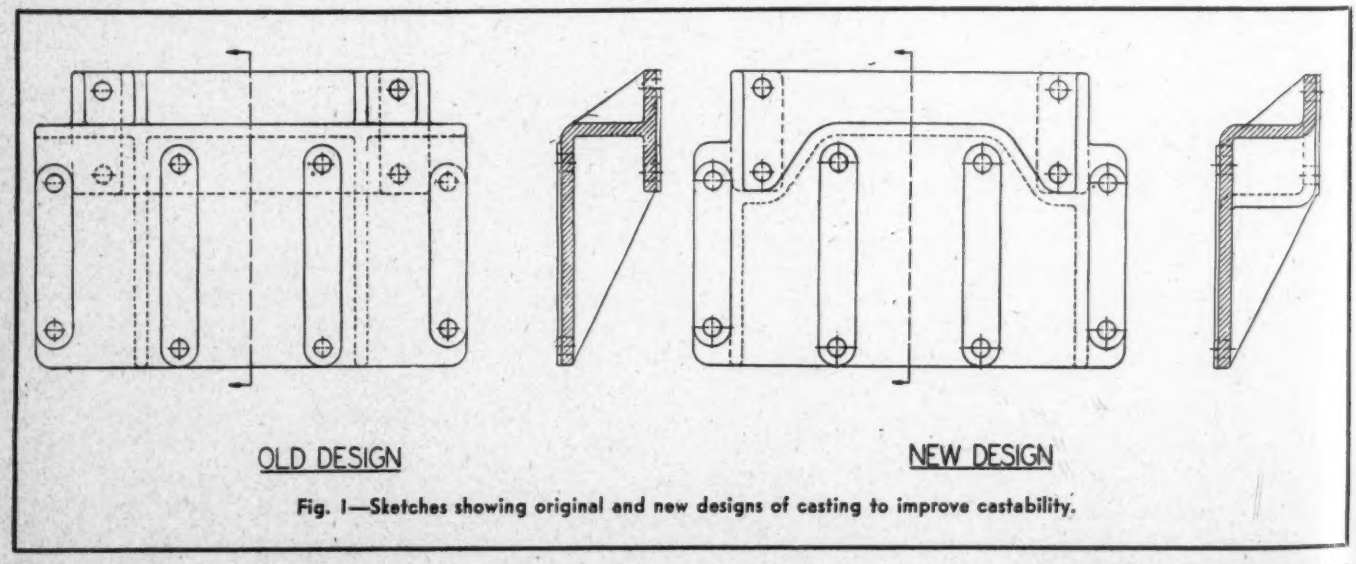


Fig. 1—Sketches showing original and new designs of casting to improve castability.

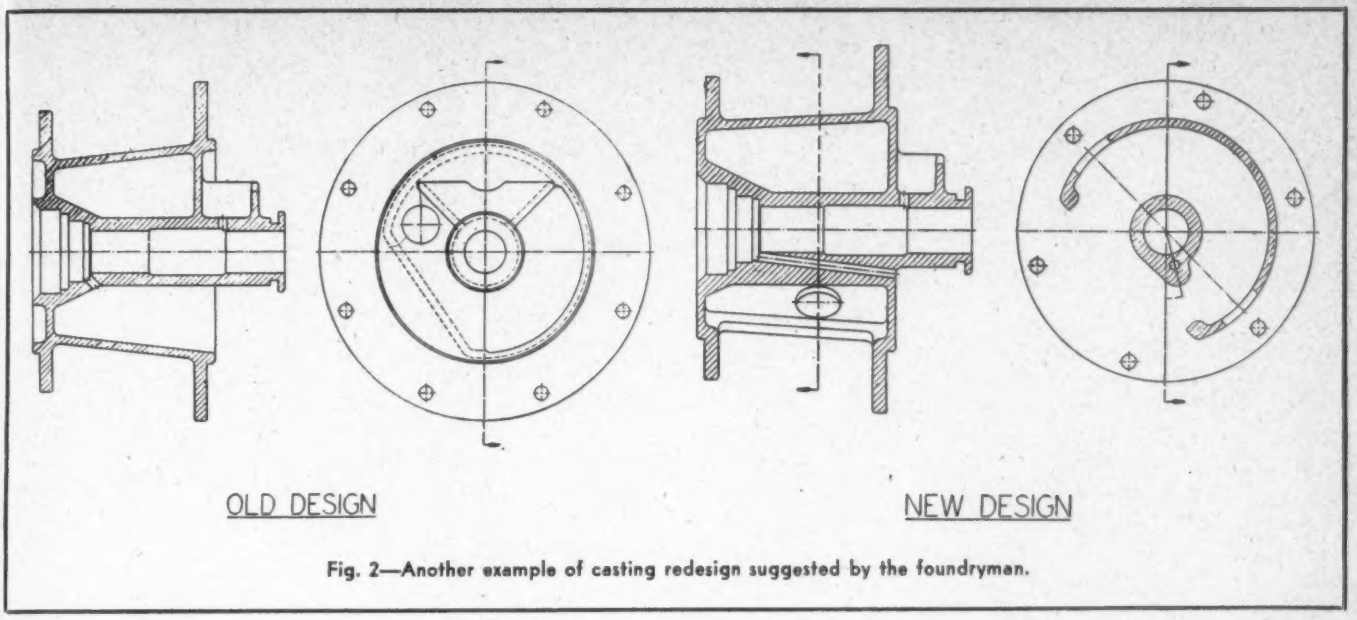


Fig. 2—Another example of casting redesign suggested by the foundryman.

prentices from all sections of the country of patterns in the A.F.A. National Apprentice Contests held in past years. It is very seldom that two of these contest patterns are designed alike. The winning pattern is chosen with moldability as being one of the main requisites.

The author might make the suggestion that moldability should be the main requisite, in order to impress future patternmakers with the importance of presenting a good, sound pattern design to the foundryman.

To design a pattern of flawless workmanship, at a low cost, accurate to perfection, only to find that it is difficult to make the core and assemble it, to make the mold at a proper rate of production, to gate properly, or to clean economically, definitely would be a waste of expensive material and man hours as far as the foundryman is concerned.

The foundry's most potential competitor today is the welding process. It is true that the foundries have proved to Army and Navy Ordnance and Engineers on several occasions that a casting is less expensive and more durable than a welded or riveted assembly. It is also a significant fact that many "would-be" castings are being satisfactorily produced from formed rolled steel parts welded together.

People who produce parts by welding have established and publicized four freedoms: 1. Freedom from excess weight. 2. Freedom from structural weakness. 3. Freedom from design improvements. 4. Freedom to use new materials where they are best suited.

This is indeed proof that the welding crafts are hoping that a good percentage of castings may in the future be lured out of the foundry and into a welding shop.

How can the foundries combat this migration? They can, and must, produce a lower cost product with equal qualifications. In order to produce castings at a low cost and at a low scrap percentage, methods and operations should be as simple as possible. The design of the pattern should be near perfection.

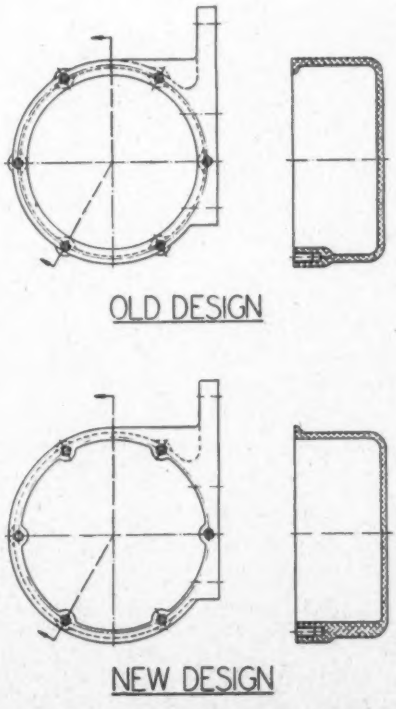


Fig. 3 — Casting redesigned to facilitate production.

In order to attain this Utopia, and it is possible, the foundryman must incorporate a pre-pattern planning and design department, or, of course, do the job himself. What is meant when suggesting a pre-pattern planning and design department?

A department of this type could consist of only one person, a drawing board, and a few colored pencils. In short, this department should be the place where all redesigns, possibilities of interchangeability with present flask and pattern equipment, and finally the designing of the pattern equipment complete with written pattern specifications, including the smallest of details, should be accomplished.

Casting Redesign. When speaking of redesign it is meant, of course, to give any part a thorough study in order that all possible cores be eliminated, that the blending of radical unequal metal sections be accomplished, and that proper core supports, partings, etc., are brought to the designer's attention prior to the making of the equipment.

This necessitates a selling proposition, so to speak, to the designer himself, and also a full understanding of the mechanics of the casting. Any redesign proposals that a foundryman may take to the designer should be based on three principles:

1. Will it reduce the cost of the part, or lower percentage of scrap?

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Patternmaking Division of A.F.A.

2. Will it enhance the mechanics or increase machine shop cost?

3. Will the appearance of the casting be impaired?

If these simple questions can be favorably answered by the foundryman, it seems entirely probable that the engineer will accept the modification suggested, provided, of course, that the functional qualities of the part will be maintained.

Figures 1, 2, and 3 show rather radical redesigns suggested by the foundryman to the engineer which favorably answered all three of the foregoing questions, and consequently were accepted.

The suggestion of a possible change or redesign to an engineer or a designer can have far-reaching effects. It is human nature to resent anyone suggesting even helpful revisions in our handiwork.

If we were to design and build a home, and upon its completion a neighbor were to make a critical remark about the placement of the bathroom, we would no doubt resent criticism even if well founded.

Yet, were we to build another home, is it not true that we would give the placement of the bathroom a great deal of consideration? This also is true with designers and engineers. All suggestions made may not be accepted, but each, if basically sound, will assist in the designing of future castings.

Interchangeability of Pattern and Allied Equipment. How far should we go in designing a pattern which will be interchangeable, or use a part of similar set of equipment?

It has been the author's privilege to have witnessed in operation a small foundry, newly designed, in which the mold conveyor system was comprised of three individual floor-type conveyor units. Each unit is designed to accommodate a certain area flask with consideration to the weight of the casting.

Standardization of flasks in this case is accomplished. Expensive floor space is saved, the storage of flasks in the yard is no longer necessary, not to mention the savings brought about when eliminating the need for additional flask equipment.

Flasks. In the foundry with which the author is associated the interchangeability of flask equipment has been utilized as much as possible. For example, there is one flask in which 31 individual cope and drag patterns are run. Practically all of the medium sized cope and drag flasks are used to make two or more different types of castings. These castings range from flywheels with extremely heavy sections to oil pans with extremely light sections.

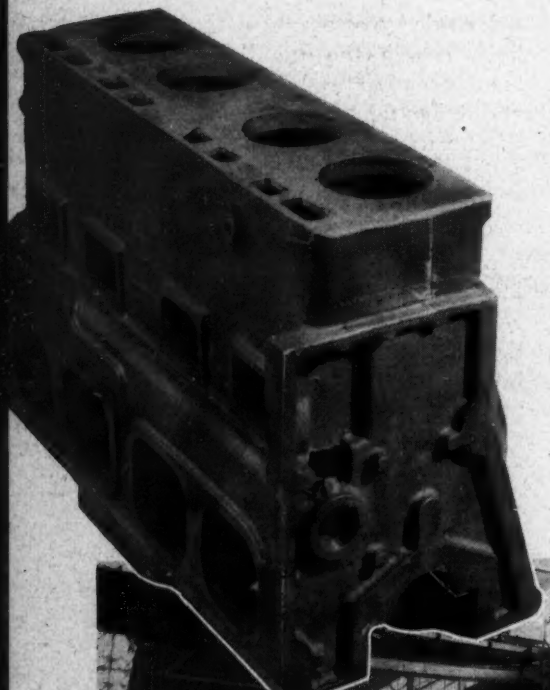


Fig. 4 (Left)—Four-barrel diesel cylinder block casting, weight 990 lb., redesigned for utilization of same body cores as in 6-barrel cylinder block (Fig. 5).

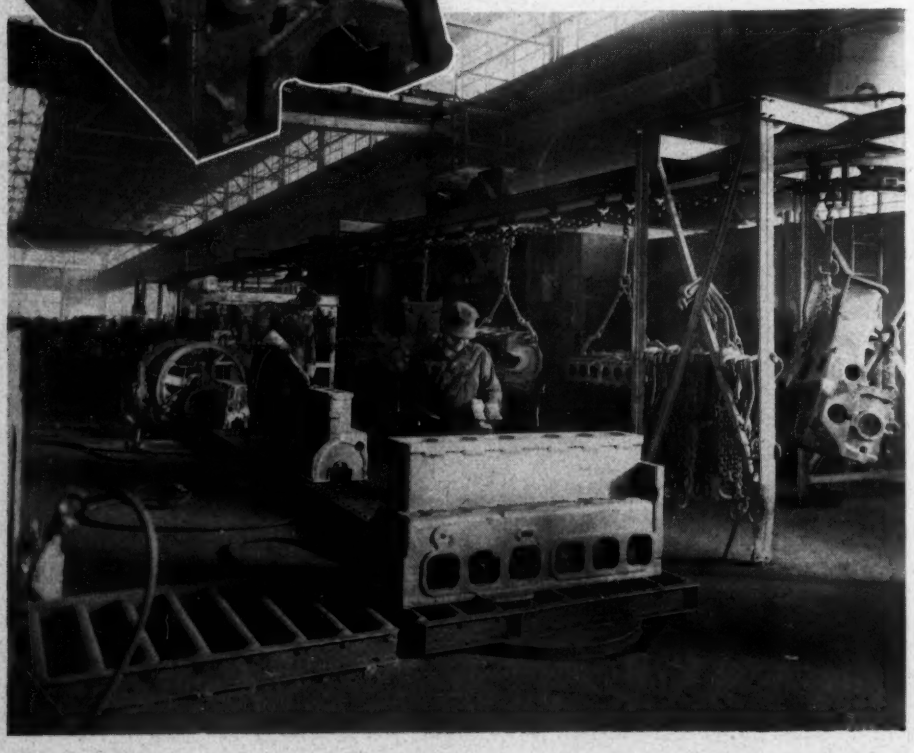


Fig. 5—(Below)—Six-barrel diesel cylinder block, weight 1260 lb., designed to utilize same body cores as 4-barrel block (Fig. 4).

Molding Machines

The interchangeability of molding machines is accomplished in the same manner. The sizes and types of molding machines have been standardized. For example, in designing the two closed flask conveyor units, only two different sized stripping machines and one size and type of rollover machine have been utilized. As a rule, rollover machines are utilized for drag molds and stripping machines for cope molds.

It has often been found advantageous to use a rollover machine for the cope mold as well as for the drag. Also, both cope and drag are run on stripping machines. This arrangement has proven very flexible and, consequently, constitutes a great saving in the rigging of patterns for machines, the ease of transferring patterns from one set of machines to another in case of breakdowns, and in maintaining this equipment with regard to interchangeability of spare parts.

Power Strip Machines

The slinger units are set up with the same principle in mind, with one exception. Only one type of molding machine is utilized. Power strip machines of various sizes are used. These machine sizes are not chosen with casting sizes or weights as the major factors; rather, each pair of cope and drag machines are purchased with interchangeability of flask sizes and pattern draw as being the main requisites.

In designing the squeezer mold conveyor unit, only one size and type of machine was installed. In regard to flask equipment used with

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

this unit, it might be stated that aluminum "pop-off" flasks are utilized 100 per cent. Here again interchangeability of flasks, achieved by designing the match plate pattern to fit a flask on hand, if at all possible, has resulted in a great saving, as well as the interchangeability of molding machines.

New sand ramming equipment and progress in the sand mixtures has eliminated to a large extent the necessity of barring the flasks to the 'nth degree to eliminate strains, sags, warps, drops and other looseram defects. This should allow us the privilege of standardizing to some extent in regard to flask sizes.

Patterns (not including core boxes, etc.). It has been the author's experience that interchangeability of cope and drag, match plate, or loose patterns, one with another, should be limited to some extent. With regard to small match plates, oftentimes it is costly to attempt to acquire two different castings from one pattern plate, with possibly changing a part number and a core print. The pattern must be taken to the pattern shop, the necessary changes made, and then returned to the foundry for production.

Cost Should Be Guide

If a monthly production is required on each casting, this would constitute approximately two changes per month, and possibly would soon cost as much or more than an individual pattern for each casting would have cost in the beginning. However, the production required from each and the cost of an individual set of patterns should be the guide in making a decision as to the advisability of interchangeable match plate patterns.

Cope and Drag Equipment. The utilization of interchangeable cope and drag equipment presents a different situation. Instances of similar copes or drags are numerous in this foundry, e.g., one cope pattern servicing six drag patterns in producing six individual flywheel castings, and in another instance, one flat-back cope plate with gating servicing three drag patterns in the production of clutch plates.

Truly, the greatest saving to be found in this foundry through pattern interchangeability is in the utilization of the same body cores in the production of six- and four-barrel cylinder blocks. This was accomplished only through the cooperation of the engineering department in consenting to incorporate major changes in the design to facilitate using one set of core boxes for both castings. These castings are shown in Figs. 4 and 5.

In speaking of interchangeability of cores, which is practiced whenever at all possible, it might also be of interest to describe and illustrate some of the universal core blowing plates and arrangements. The author will not elaborate upon the technique of core blowing, the technicalities involved and the advantages and disadvantages.

However, the changing of core boxes on blowing machines has been simplified in this foundry. As many as 18 different core boxes have been run on one core blowing machine during a 16-hr. period. In order to accomplish this, and not waste valuable setup time, standardization of blow plates must be brought about.

In one instance a universal blow plate was developed, as illustrated in Fig. 6, which can be used to blow a certain size and type of core. The box to be blown must necessarily have one open end for sand-laden air to enter. Due to the design of this blow plate, a minimum number of blow vents are required in the box itself. Approximately 3 to 5 min. are required to change from one box to another.

Figure 7 shows a few of the type of boxes that can be blown with the blow plate and vent plates shown in the foreground. Figure 8 shows the disassembled blow plate. In Figs. 9 and 10 is illustrated another labor saving blowing arrangement. Both cores illustrated are used for the same casting, and both are blown at the same time. Figure 9 shows these cores directly after blowing, and being removed from the blowing machine. Figure 10 shows the cores after they have been machine drawn, ready for baking.

It is sometimes found that the interchangeable patterns and core boxes present a problem. Due to great demands by army and navy

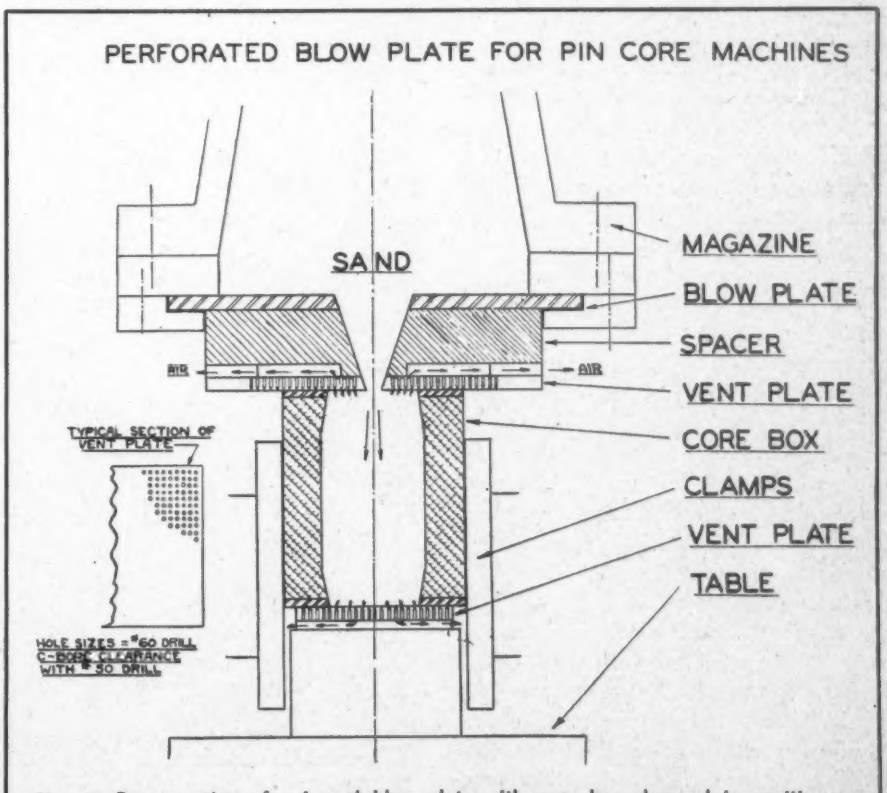


Fig. 6—Cross section of universal blow plate with core box clamped in position on core blower.

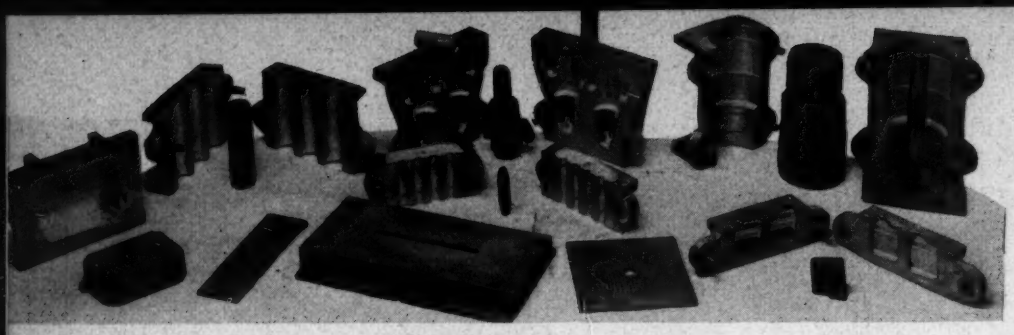
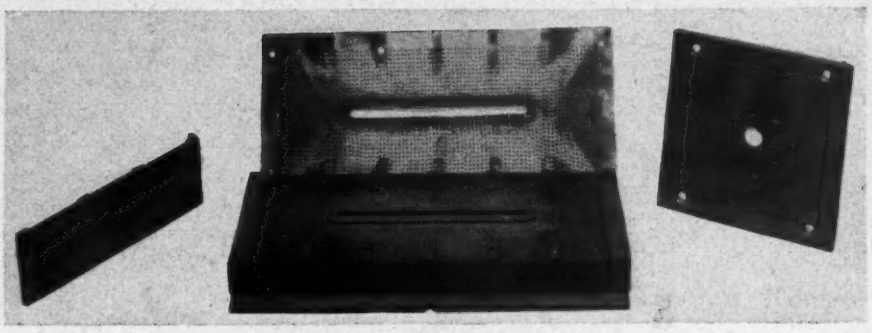


Fig. 7—(Left)—Various types and sizes of cores produced with type of blow plate shown in Fig. 6. Note lack of blow vents.

Fig. 8—(Below)—Universal blow plate (Fig. 6) disassembled.



departments, it has been necessary to job a large percentage of the castings to other foundries. Here is where the problem comes in.

It is a difficult matter to find many patterns that do not use interchangeable cores, flasks, or patterns which are not themselves interchangeable, so it often becomes necessary to locate a vendor with sufficient open capacity to absorb all of the jobs that are made with this interchangeable equipment. If the vendor can absorb all of these jobs, he of course realizes the same labor and space savings that this foundry experienced with the interchangeable equipment.

Even though the system may be "backfiring" now, the author still believes that the thousands of dollars saved through the use of interchangeable pattern and flask equipment more than offsets the problems arising from it today.

Design of Pattern and Allied Equipment. It has been stated time and again that no definite set of rules can be laid down to follow when designing pattern equipment. It is the author's opinion that this is not true. It is not the practice in this foundry to attempt the standardization of pattern equipment design, because each casting has its own special peculiarities. However, an attempt is made to follow a certain routine, or, rather, scrutinize each part with equal severity, in order to attain as nearly ideal coremaking, molding, and cleaning conditions as possible.

Following a small part through its routine will serve to check the method. The part chosen is a water pump bracket, which weighs 25 lb. and has a production requirement of approximately 5,000 pieces per year. The reason for choosing a small part with modest production requirements is to impress upon the reader the equal importance in the design of either a small or a large casting. The routine steps taken to complete this pattern are given in the following paragraphs.

1. Establish parting line on blueprint, with most consideration being given to gating. Determine which is cope or drag side. (Use oil-base colored pencil.)

2. Sketch in core prints (check for possibility of redesign to eliminate same) and sketch in loose pieces, if they are found to be necessary, giving full consideration to the making and setting of cores. Sketch crush strips and close-over clear-

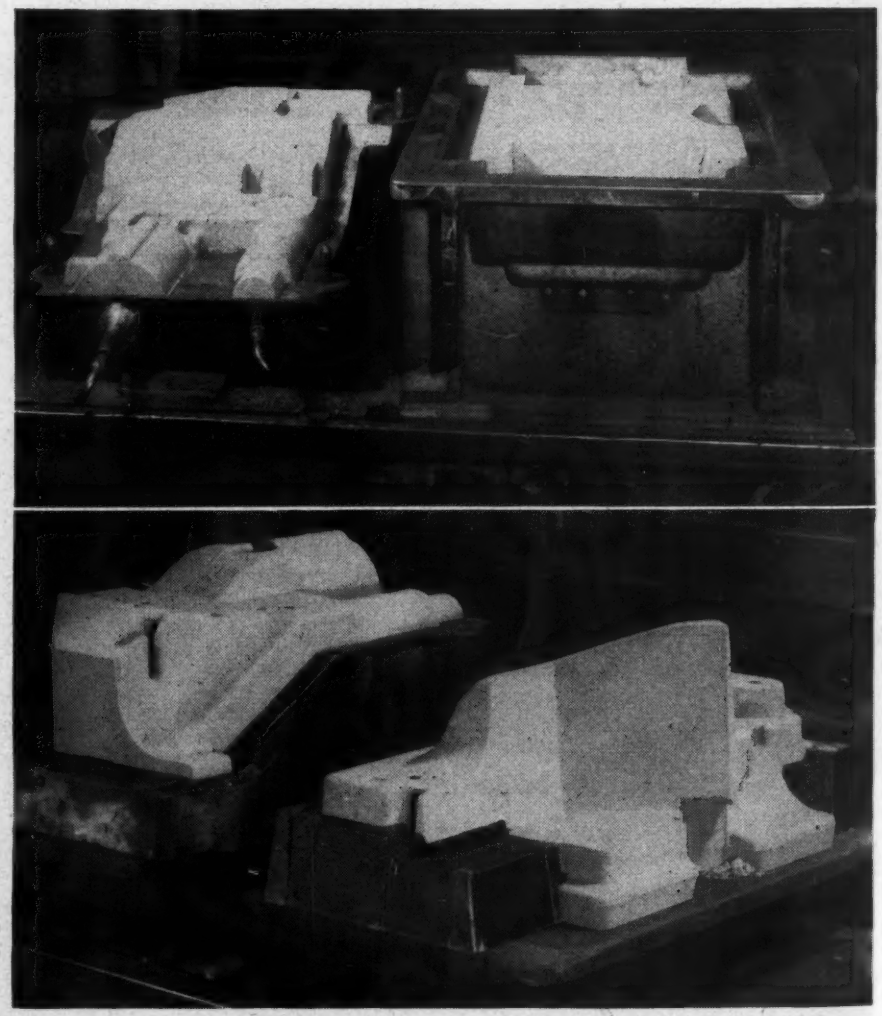


Fig. 9 (Top)—Both cores are for the same casting and are blown at the same time. Note boxes tied together with rail at bottom. Fig. 10 (Bottom)—Cores (Fig. 9) after drawing and ready for baking.

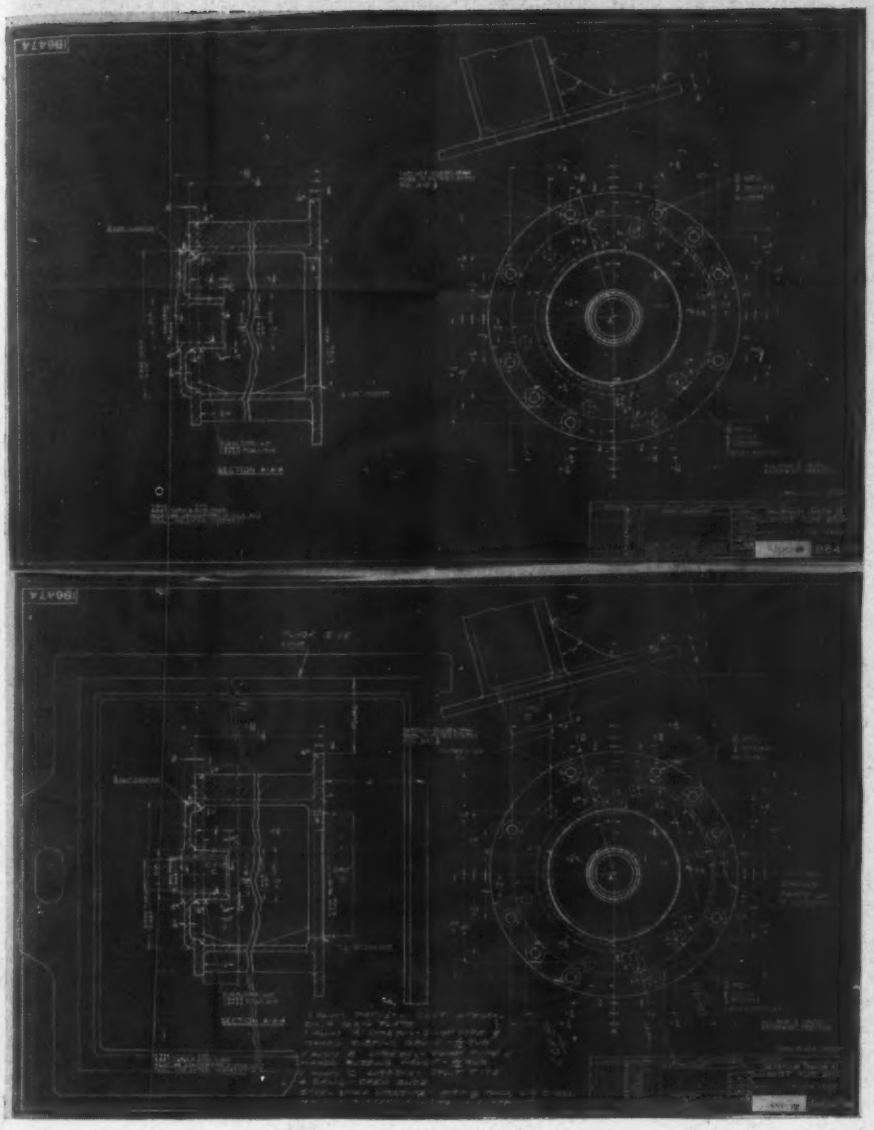


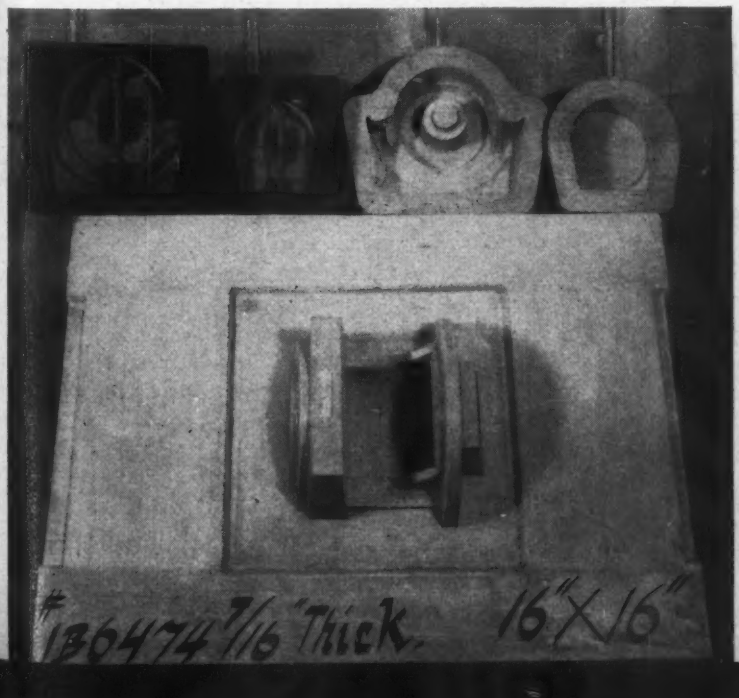
Fig. 11—Upper blueprint is compiete as received from engineering department. Lower blueprint is complete after pattern designing has been accomplished. See Figs. 12, 13, 14 and 15 for various stages to finished casting.

Fig. 13—Partially completed mold of aluminum match plate (Fig. 12).

Fig. 14—Sand-cast aluminum match plate with pattern being machined for accuracy.

Fig. 12—Soft pine master pattern mounted in match board to produce aluminum match plate.

Fig. 15—First sample casting obtained from completed match plate equipment (Figs. 11, 12, 13 and 14). Note layout lines.



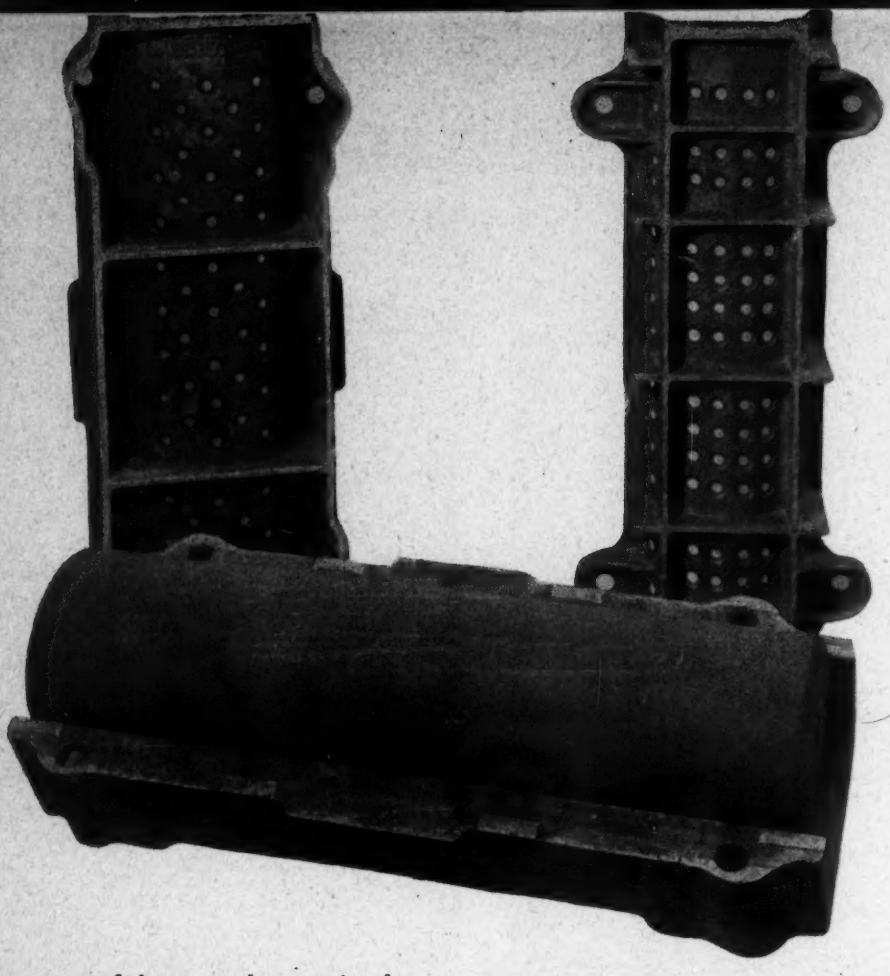


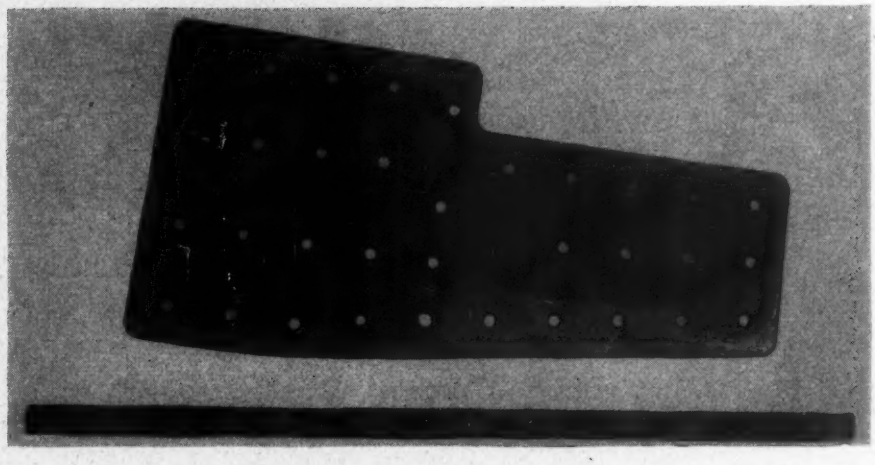
Fig. 16—New (left) and old (right) designs of cylinder liner core dryer.

in both warping and breakage. Approximately every 4 months the entire group of dryers were taken to the pattern shop for straightening, and continual replacement of broken dryers was necessary. Also, this dryer often tipped over after being placed on the core rack.

These disadvantages made necessary the designing of a new dryer and, finally, the design shown on the left in Fig. 16 (with the core at rest in front) was adopted. This is a box-type construction, and is considered to be a non-rocking, non-warping, non-breaking dryer.

Three hundred of these dryers have been used in continuous production for 4 years. One dryer has been broken, and they have yet to be reworked in any way. This de-

Fig. 17—(Below)—Specially designed aluminum core plate. Note construction to insure better baking of plate surface of core.



ances, and letter each core in the sequence in which it will be placed.

3. Sketch outline of plate and flask around pattern, allowing ample room for proposed gates and risers.

4. Provide written pattern specifications in detail, specifying pattern material and any allied equipment, such as core rubbing or grinding fixtures, dryers or special core plates.

5. Check layout for any item that can be provided to eliminate the possibility of any discrepancy that may arise.

Figures 11, 12, 13, 14, and 15 illustrate, in part, the growth of a casting from the blueprint to the cleaned casting.

Hints in Designing Core Dryers and Core Plates. A core is seldom more accurate than the dryer or plate on which it is supported until baked. As a rule, foundrymen are apt to slight the design and maintenance of core dryers and plates. Figure 16 shows two designs of core dryers. Both dryers are used to bake the same core.

The old design, with all ribs and the four dowel pin lugs protruding from the dryer, is shown on the right. This design was very costly

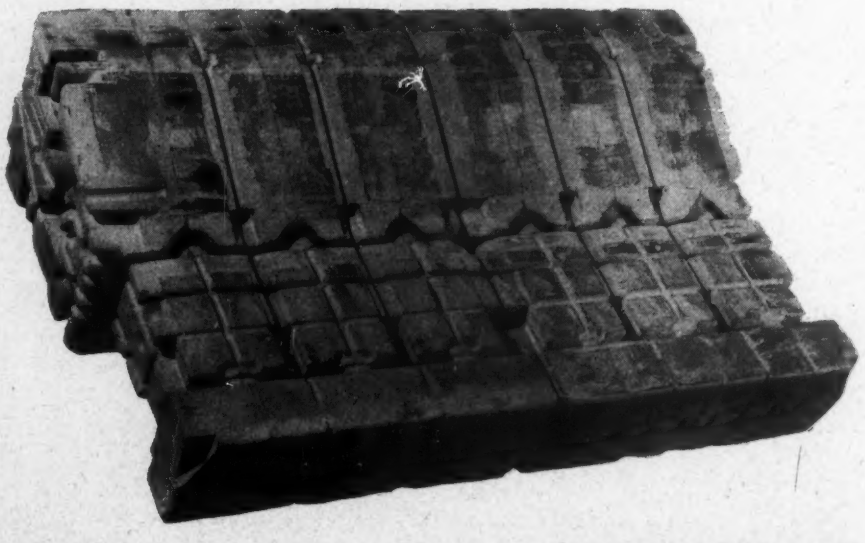


Fig. 18—(Right)—Complete assembly of body cores necessary to cast six-barrel cylinder block shown in Fig. 5. Cores are not rubbed on the joint. Over-all assembly allowed ± 1/16-in.

sign has been extended to all types of core dryers wherever possible, with the same results.

In Fig. 17 is shown a specially designed aluminum core plate which is used to support the diesel cylinder block cores during baking. Prior to the use of this core plate, numerous designs and materials were used, all with the same results. The cores would not bake out on the plate surface, or the plates themselves would warp, which made it necessary to grind the cores in a fixture.

After designing the type of core plate shown (Fig. 17), the cores were found to be flat and it was possible to eliminate the grinding operation, which resulted in a direct saving in labor, plus the fact that the cores which are not ground are more accurate than those which are ground.

Figure 18 shows a complete six-cylinder diesel body core assembly ready for the mold. Twelve cores are bolted together and are held to an over-all length dimension of plus or minus 1/16-in.

Prior to using this present plate, a cast iron plate was used. Two men were required to lift the cast iron plate upon the box, whereas with the present aluminum plate only one man is needed for this operation.

The design of the aluminum plate is such that there are two 7/16-in. thick parallel faces, vented as shown in Fig. 17, tied together with ribs and bosses of equal metal thicknesses. The plate was cast, annealed at 700° F., and then machined on both surfaces. The top and bottom plates are 1 in. apart, allowing the free circulation of hot gases and even heating and cooling.

For foundrymen to close their eyes to the competition offered by the welding and powder metallurgy processes would be dangerous indeed. Methods of producing castings at lower costs and with closer tolerances must be developed. It cannot be expected that foundry raw materials will cost less. Rather, because of shortages, the foundryman must be prepared for higher material costs. Only through the development of methods to increase production, labor saving foundry equipment, and progress in pattern design can the foundryman hope to compete.

GOLDEN ANNIVERSARY

Convention Programs Being Formed

(Continued from Page 29)

the use of models in the planning and construction of patterns.

Steel

The Steel Division is planning three 2-hour sessions and one Round Table Luncheon. Seven, and possibly more, papers will be presented, two authored by Russian foundrymen. The other papers will cover the low temperature properties of certain cast steels, thermal relief of residual stresses, methods of quality control, methods for control of hardenability, and various types of blind risers. Other subjects such as bore cracks, homogenization and intergranular fracture are possibilities.

The Steel Division is also planning to hold a Round Table Conference of the "off the record type," the program for which will only be of a skeleton nature so that discussion may be stimulated.

Aluminum and Magnesium

The Aluminum and Magnesium Division is planning a series of sessions on a variety of subjects, ranging from the very practical to the metallurgical type. One of the features of the Aluminum and Magnesium Division program will be a breakfast session similar to the one held several years ago, in which there was great interest. At a recent meeting of the Aluminum and Magnesium Division, Program and Papers Committee, enthusiastically attended, large number of papers were promised. Further details regarding the plans of the Division will be announced later.

General Interest Sessions

Research and Education

As previously stated, the number of general interest sessions will be held throughout the convention week. At least two sessions will be devoted to developments in foundry sand research and will include the presentation of the last two progress reports on the work being conducted at the Cornell University, Ithaca, N. Y. It is proposed to hold a session on heat transfer, at which time progress made in the research on this subject at Columbia University, New York, will be discussed.

Several sessions pointed at the Educational Program of the Association, recently announced, will be held. It is hoped that a joint session on this subject may be arranged with other Foundry Industry organizations and definite plans are under way for a session planned by the Committee on Cooperation with Engineering Schools. Other sessions of training and educational nature will be those on apprentice training and foremen training.

Apprentice Contest

This year again the annual apprentice contest in gray iron, steel and non-ferrous molding and pattern making are being held, and the winners of the respective contests will be guests of the Association for a portion of the convention.

Sessions are also being planned by the Committees on Foundry Costs, Inspection of Castings, Job Evaluation and Time Study, Plant and Plant Equipment, Refractories, and Safety and Hygiene. The usual Sand Shop Course will be staged again this year and an interesting program has been assured by the committee, which plans a minimum of three sessions. A possible additional session may be staged by the Committee on Chemical Analysis.

Lecture Course

A past feature of conventions of A.F.A. has been the annual lecture course. This series of meetings has been a very popular feature. This year the subject chosen by the Annual Lecture Course Committee is "Foundry Control Methods." It is not anticipated that a full discussion of this subject can be held this year, and plans are being laid to continue the series at the 1947 meeting, after which it is hoped that the lectures will be made available to foundrymen in book form.

From the above, members of the A.F.A. will realize that since V-J day, many committees have been busily planning for the technical sessions of the 50th Anniversary Convention. The success of any technical program will be due to the efforts of those individuals and companies in the metal casting industry who are sufficiently interested to give of their time, effort and knowledge that the industry may progress.

Other Non-Destructive Methods of Testing

By John W. Juppenlatz, Chief Metallurgist,

Lebanon Steel Foundry, Lebanon, Pa.

• Agreement upon standards for interpretation of defects revealed by non-destructive testing methods is the controlling factor in the value of these methods as a test means. Workable standards, based upon the essential service of the material tested, should provide for ready definition into acceptable and non-acceptable classifications.

THE subjects, radiography and magnetic particle inspection, cover two basic, well-known and reasonably well established methods of non-destructive testing. First, the radiography method may be applied to diversified castings of any metallic composition, with x-ray fluoroscopy for sections of low density; second, the magnetic particle test is limited to and can be applied only to magnetic materials, diclosing defects at and near the surface.

Other methods of non-destructive testing, applicable to castings, have proved to be of practical importance, with still others in the process of experimental development. Several of these methods are used as independent tests but employed as supplemental aids to radiography. Some of the better known methods will be briefly considered in the following discussion.

Penetrant Materials

For many years foundries have recognized the value of applying a light machine oil to the surface of castings, allowing time for its penetration into surface defects, then removing the excess surface oil with a light sand blast. This leaves the surface with a light colored silica dust on all areas except those containing defects such as cracks and surface imperfections, which are soon discolored by oil returning to the surface.

This method is a deviation of the well-known "whiting" method. Further development employs the use of a fluorescent penetrant on castings, with the subsequent examination made under ultra-violet light. This method was publicized by T. DeForest in 1942[1], and since then by others.

The fluorescent method, developed by the Switzer brothers with patent application in 1938, is obviously more sensitive than the whiting method and has become a reasonably well established method of non-destructive testing for foundry inspection. It is not limited to size of casting nor type of analysis. However, defects must be of surface origin for detection. Subsurface defects are not disclosed. Internal shrinkage may be indicated only when the defect is continuous to the surface of the casting.

Application Range

The application of this penetrant fluorescent method is not confined to non-magnetic castings. Results compare favorably with the magnetic powder test in disclosing defects that are apparent on the surface; however, it does not indicate slight subsurface defects, even though this defect is a continuation of the apparent surface defect, such as often experienced with the magnetic particle test.

Demagnetization of castings, which is occasionally necessary when using the magnetic particle test, is not required. The penetrant fluorescent method is often used on castings where intricate shapes of magnetic castings causes difficulty in the introduction of the required magnetic-flux-density.

The process, equipment and materials for the penetrant fluorescent inspection of castings is comparatively simple. The first requirement is the preparation of the casting, which should be well cleaned of such surface irregularities as tend to form extraneous cavities, including sand or scale.

The casting may be immersed in a tank containing a light penetrating oil chemically treated for high fluorescent brilliance and water solubility. In lieu of dipping, the oil may be brushed or sprayed on the casting surface, but when size permits, total immersion is preferable. Ten min. time of immersion for oil penetration is considered sufficient for most applications.

Excess oil is allowed to drain from the castings for re-use. The adhering surface oil must be washed off, preferably by clean, hot water. Emulsifying action of the water is greater when hot, and a nozzle effect aids in the surface cleaning of fillets, etc. A water dip, followed by a spray rinse, leaves the surfaces smudgy and is not recommended. With the castings warm from the hot water rinse, air drying is quickly accomplished and the casting is soon ready for inspection.

Examination Conditions

Castings may be inspected immediately, but are preferably given sufficient time for the penetrant to return to the surface in case defects are present. A darkened room is required for visual examination under "black light" or near ultra-violet light which is not registered by the human eye.

After a few minutes for adjustment of the eye, defects appear to fluoresce where the penetrant oil has returned to the surface. Depending upon the time elapsed from rinse to examination, an experienced operator can distinguish the relative form and dimension of the defect by the amount of penetrant being ejected to the surface.

An alternative method of process-

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Steel Division of A.F.A.

ing employs the use of an absorbent developing powder which is applied to the casting surface in excess after the normal hot water rinse. This developing powder tends to draw the penetrant from the defects and cause a higher degree of contrast between the defect and the background. This method is not generally used on as-cast surfaces, since it is an additional operation which does not appear to aid in disclosing real defects.

Inspectors soon become trained to visually distinguish between defects and what might be termed blemishes or surface sand particles which might trap some penetrant. On the other hand, cracks or other significant defects are very apparent. These defects, after being located and marked, can be removed by chipping or grinding.

Re-examination of Defect

When the chipper is not certain of complete defect removal, it is possible without any reprocessing to re-examine the casting defect under the "black light." If any portion of the defect remains, it will fluoresce as long as the penetrant remains within it.

Some of the advantages of this method of inspection are cause for its rapid gain in popularity. The operating cost of testing is low as compared to radiography. Equipment and materials are readily accessible without large expenditures. However, it is limited to disclosure of surface defects only.

By preliminary fluorescent penetrant inspection of castings, such defects as may be disclosed can be repaired before final radiographic examination, thereby saving considerable time and expense when a re-radiograph of the repaired casting is required. This method may disclose defects which are not indicated on radiographic negatives due to their size or direction. It therefore does not replace radiography, but supplements it.

Loading Tests

Static loading non-destructive tests of castings are commonly being applied to finished structural components to prove their suitability for the service intended. Many of the parts are subjected to predetermined live-load tests simulating service conditions, followed by measurement of the amount of deflection and permanent set when the load is released.

This type of non-destructive test determines not only the quality of material but is often used in the development of satisfactory designs. For proof tests, these parts are subjected to stresses well below the elastic limit, with the usual specifications not allowing any permanent deformation. Loading is usually one and one-half times or more than the maximum service loads, and this test segregates castings or designs with substandard strength.

Static proof testing is often applied to castings with known defects as disclosed by other methods of non-destructive testing. These castings are proof loaded, checked, and reloaded with increased loads until permanent set or destruction has occurred.

This information, coupled with actual service results, aids in establishing the permissible extent of casting defects allowable with some margin of safety. Location of defect with size, type and direction as disclosed by other non-destructive tests should be taken into account, thus forming workable standards of acceptance or rejection for the parts involved.

Testing Pressure Castings

Hydrostatic testing of pressure type castings has superseded practically all forms of non-destructive testing. It is being regularly applied as a final inspection method to fittings at standard pressures in excess of their normal working pressure, even though radiographic and other non-destructive tests have been applied. Air pressure tests, at pressures often greater than the working pressure, are common with the castings immersed in water.

An air test of unmachined pressure fittings is frequently applied in foundries, using a water-soap solution and observing any bubble formation indicating unsoundness. Likewise steam, cold and hot oil pressure tests are used. Any of these tests are for the purpose of segregating "leakers" or defects which pass from wall to wall of the casting.

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

Acoustic Tests

Acoustic tests, such as striking a casting with a hammer to determine if it "rings true," are old. A modification of this method includes the use of the medical stethoscope. The results of this test are largely dependent upon the operator's skill in making and receiving the vibrating sound waves that are only qualitative or indicative.

Supersonic Tests. Supersonic or ultrasonic waves with frequencies beyond the range of audible sound are reported to have been used for several years in Russia[2], Germany[3], and other countries[4].

The application of supersonics to castings in this country has been limited to special applications and could be generally expressed as being in the experimental stages. Obviously, this method can be further developed so as to be an important means of non-destructive testing.

Supersonics Development

A communication from R. H. Wallace (Sperry Products, Inc., Hoboken, N. J.) describes an American development of the supersonic reflectoscope for testing castings:

"In testing by means of the supersonic reflectoscope, supersonic vibrations are sent into the material under test by means of an ocillator with a pulse circuit which sends out "trains" of vibration. Each pulse of vibration penetrates the material and reflects from the opposite side or from intervening defects to re-energize the sending crystal which has ceased to vibrate during the period in which the pulse oscillator is not functioning. This reflection is then amplified and placed on an oscilloscope screen. Pulses are at a frequency of 60 per second and reflections are therefore superimposed continually at this rate on the screen and appear as a continuous picture, showing at the left of the screen the sending pulse and in sequence from left to right any reflections of the original pulse, with the time intervals, which can be calibrated directly in inches of penetration, being read directly off the screen. By the degree of absorption of these reflections in

the various materials a relative indication of grain size is given.

"In the application of this equipment to castings the grain size and porosity play a limiting factor, since the larger these are the greater will be the absorption of the vibrations and the resultant difficulty in penetrating the material. In most cases, however, ample penetration can be obtained if the defects which it is desired to find are not too small. For accurate determination of whether the reflectoscope can satisfactorily test castings, it is necessary to consider each application individually as to its shape, surface condition and absorption to supersonic vibrations. The size of defect which can probably be detected can then be predicted with reasonable accuracy.

"In applying the reflectoscope to a test piece, a flat or curved crystal is placed against the material with a film of oil in the inner face to improve the transmission of the vibrations. In some applications the "as cast" surface is sufficiently smooth but in others it would be necessary to use a small hand grinder to smooth off the rough spots."

According to A. Behr[4], the supersonic method in foreign countries has reached an advanced, although by no means, a final stage of development. Also, that the outstanding merit of the ultrasonic method is undoubtedly its ability to disclose defects which do not represent a sufficient change in "density" to enable their detection by x-rays.

Thus, cracks or lamination situated in a plane at right angles to the supersonic beam can be detected with certainty. Another advantage is the ability to deal with cross-sections of metal which could not be penetrated by x-rays or even gamma-rays.

The principle feature which hinders the development of supersonics for castings is the present difficulty of interpreting the results with certainty. Available equipment is highly sensitive to surface irregularities and minute blemishes. When these difficulties are overcome, this instrument may gain in use and popularity for non-destructive testing.

Other Electrical Methods

Other electrical methods of flaw detection in castings have been tried with limited application and degree of success to castings. One method involves the direct passage of current through the casting by brush contact and the measurement of the surrounding field set up by this current, similar to railroad rail inspection (Sperry). This electromagnetic method is limited to uniform longitudinal sections and does not lend itself to castings with variable or diversified sections.

Another electrical method, applicable to magnetic or non-magnetic materials, is the induction of current to its saturation point if magnetic, or partial saturation if non-magnetic, and measuring variations in the field as set up by this induced current. This method discloses flaws or changes of metal sections and is now commonly applied to bar stock or tubing as acceptance methods, but not to general castings due to variation of design.

Analysis and Structure

Still other electrical methods have been developed utilizing electrical principles, one of which employs a direct current in testing the thickness of a casting wall from one side only[5]. The potential drop caused by the flow of current is used to indicate wall thickness. These electrical methods require standard pieces of similar design with complete soundness for comparison. Due to diversified casting sections, this method of non-destructive testing remains limited.

Reference to methods of non-destructive testing for the purpose of segregating materials of varying analyses and states of heat-treatment should be included since such methods are in practical use for castings, but are not employed for the purpose of disclosing defects or flaws.

One of these instruments is based upon the principles of thermo electricity[6]. This test makes use of a known test piece, which is set up as one side of the circuit and in contact with an unknown test sample involving the other side of the circuit so that there is a mutual point of contact. With auxiliary electrical current input, the temperature at the point of contact increases, and if the metals are dissimilar, an electromotive force will be indicated on the instrument.

The test pieces act as the thermocouple and the instrument as the galvanometer. Materials have been segregated and checked for similarity of analysis, as well as conditions of

A development in the supersonic method of testing.

structure and heat treatment. The process of test is quite simple and requires only a piece of known material for comparison. Its use on finished articles may be objectionable due to occasional marks of electrical contact.

The cyclograph[7], an electronic instrument, utilizes the principle of varying metallurgical properties which cause variation in the core loss of a tuned pick-up coil which surrounds the piece under test. This variation affects the shape of the visible pattern or cyclogram displayed on cathode ray tube indicator screens. This instrument, while in the stages of development, refinement and practical application, is limited to uniform casting sections which can be inserted into a suitable test coil.

Standardization of cyclograph patterns with known materials can easily be made so that analysis and condition of heat treatments of identical production shapes can easily be checked for uniformity. Differentials of analysis, structure, depth of hardness or variables of heat treatment now are being checked with this method on malleable iron and steel castings.

The development of a suitable test coil for general casting inspection would permit wider application and use of this electronic method for inspection of finished castings in lieu of some of the testing methods being applied which could be classed as destructive tests. This instrument is not appreciably affected by casting defects and therefore is not recommended for that purpose.

Summary

The limiting factor controlling the use of non-destructive methods of testing for castings involves the correct interpretation of the results. Any method, in order to be practical, must be accepted by the foundryman. It should not reveal false indications and should be capable of readily defining defects into acceptable or non-acceptable classifications without too much controversy.

Standards of acceptance are becoming more critical with time and inspection methods are constantly being improved, such as witnessed by radiography within the past decade. Therefore, before any non-destructive method of testing for castings is established as a test means, a set of workable standards should be agreed upon which distinguish between flaws or blemishes and real defects which may affect the ultimate service of the casting.

Some deviation from casting perfection is unavoidable, and any method of non-destructive testing can survive only when proper emphasis is placed upon working standards and with due regard to interpretation based upon essential requirements.

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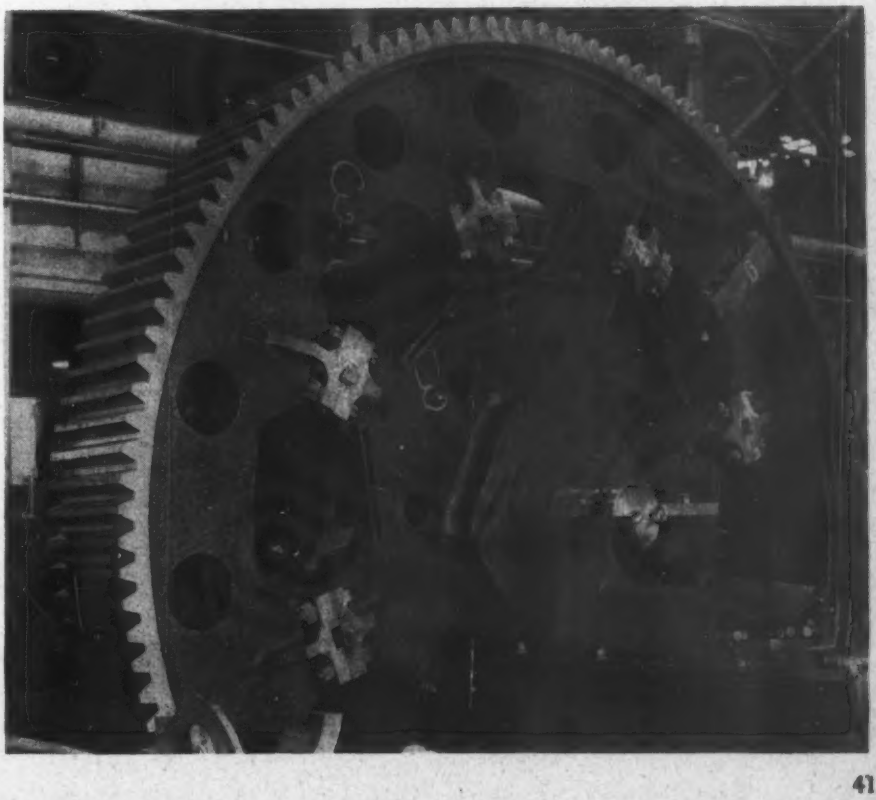
YOUNGSTOWN FOUNDRY
Makes Giant Gear for Steel Plant

ONE of the largest and heaviest gears was made recently at the United Engineering & Foundry Co., Youngstown, Ohio. The cast steel gear, a giant that weighed 138 tons and measured slightly more than 21 ft. 6 in. outside diameter, was designed as a plate mill drive for a Chicago steel plant. The gear was so large and heavy that normal railroad cars and railroad clearances could not accommodate it. Consequently the gear was cast in two pieces. It was then shipped in separate freight cars to Chicago and welded into one solid piece.

The gear had an over-all face width of 74 in., and had 128 cut teeth. The gear was made in five pieces.

Giant gear recently made at United Engineering & Foundry Co., Youngstown, Ohio.



Malleable Sand Control

Summary of Questionnaire

• *A summary of the answers of some 14 companies to a questionnaire on malleable sand control, to be included in the symposium with the several papers prepared at the request of the Malleable Division Program Committee as the Division's contribution to the 1945 Program. The ultimate objective of the Division is to later incorporate all of these symposia in a book on malleable foundry practice. Previous symposia covered (1) Graphitization of White Cast Iron, (2) Malleable Iron Melting, (3) Gating and Heading.*

TWELVE questions, designed to give a broad picture of malleable sand control practices, are answered by 14 plants. The reports given by all plants are listed under each question.

1. Type of castings produced.

Plant No. 1—Tractor, light and heavy duty trucks, agricultural implements including chain links and roller bearing ends, and Ordnance castings.

Plant No. 2—Automotive castings such as large housings weighing up to 80 lb. down to very small castings. Jack parts, such as gears, bases and frames are also produced.

Plant No. 3—Railway, tank, anti-aircraft, prime mover M-6, etc., of Ordnance.

Plant No. 4—Automotive, agricultural, Ordnance.

Plant No. 5—Pipe fittings.

Plant No. 6—Pipe fittings and small valves.

Plant No. 7—Railroad casting, 80 per cent of production; gear housings for road machines.

Plant No. 8—Railway, agricultural implement, auto accessories, and general miscellaneous.

Plant No. 9—Electrical apparatus.

Plant No. 10—Tractor axle housings, truck differential housings, differential cases, etc.

Plant No. 11—Automobiles, hardware, railway, conveyor castings.

Plant No. 12—Malleable chain and job castings.

Plant No. 13—Ordnance work, truck, tank, railway, hardware, farm implements.

Plant No. 14—Mostly truck and tractor castings.

2. Are the castings produced of a jobbing nature or are they used in the company product?

Plant No. 1—Almost all castings are used in company products.

Plant No. 2—Jack parts are used in the company product. The bulk of work is for outside customers.

Plant No. 3—Jobbing.

Plant No. 4—Of jobbing nature.

Plant No. 5—Ninety-five per cent product. Five per cent jobbing.

Plant No. 6—Used in company product.

Plant No. 7—Railroad castings produced for company's end product—brakebeams and freight car door parts. Gear housings and miscellaneous jobbing castings on jobbing scale.

Plant No. 8—Jobbing nature.

Plant No. 9—Company product.

Plant No. 10—Castings produced are company product, cast in production quantities.

Plant No. 11—Both company product and jobbing.

Plant No. 12—Seventy-five per cent used in own product and 25 per cent job castings.

Plant No. 13—Jobbing.

Plant No. 14—Strictly a jobbing foundry.

3. Average weight of castings.

Plant No. 1—Average weight, 0.8-0.9 lb.

Plant No. 2—Great variation in casting weights. Average about 10 lb.

Plant No. 3—Six lb.

Plant No. 4—From 2 to 3 lb.

Plant No. 5—From ½ to 50 lb.

Plant No. 6—One lb.

Plant No. 7—Railway castings average 22 lb. Jobbing castings average 32 lb.

Plant No. 8—Average of 1.5 lb.

Plant No. 9—Average of 4.7 lb.

Plant No. 10—The average weight of castings produced would be about 50 lb. These range from 15 to 65 lb.

Plant No. 11—1½ lb.

Plant No. 12—0.4 lb.

Plant No. 13—7 lb.

Plant No. 14—11.4 lb. (approx.).

4. Are special casting finishes necessary, such as special grade, fine, or can they be medium, or is smoother surface demanded?

Plant No. 1—We need a very smooth finish on chain links, roller bearing ends and many other very small castings. The heavier tractor and truck castings may have a medium finish.

Plant No. 2—Medium finish.

Plant No. 3—A relatively smooth surface is required—all castings varying in degree by the size of the casting.

Plant No. 4—For our general line of work a medium finish is satisfactory. Light work requires a smoother finish.

Plant No. 5—Surface suitable for galvanizing.

Plant No. 6—Fine finish.

Plant No. 7—Railway casting finish, medium; jobbing castings, fine.

Plant No. 8—Some few jobs require a finish smoother than that obtained by wheelabrator cleaning, and they are usually handled with sand blast using grit.

Plant No. 9—Medium finish.

Plant No. 10—No special finish or smoothness is required.

Plant No. 11—Medium finish.

Plant No. 12—25 per cent fine finish, 75 per cent medium finish.

Plant No. 13—Casting finish is medium on most work; just a few jobs need a special finish.

Plant No. 14—Medium surface conditions prevail.

5. Does plant have sand handling equipment, and is the sand supplied to the molders by continuous system, periodic or by heaps?

Plant No. 1—We use a sand sling-

er on one large floor but all squeezers and machine molds are worked from heaps.

Plant No. 2 — Molders are supplied by heaps.

Plant No. 3—A No. 1½ muller type pan mixer. By the wheelbarrow full.

Plant No. 4—No. Sand is supplied to molders by heaps.

Plant No. 5 — Continuous sand handling.

Plant No. 6 — Continuous sand handling system.

Plant No. 7—Sand reconditioning available; facing sand prepared and furnished to molders by trucking. Some heap sands on side floors.

Plant No. 8—No.

Plant No. 9—No sand handling equipment.

Plant No. 10—Sand is supplied to the molders by a continuous system.

Plant No. 11 — Yes, continuous system.

Plant No. 12—Individual heaps only.

Plant No. 13 — Two continuous systems (slinger and hopper lines); one-third of plant operates by heaps and facing.

Plant No. 14—No. 1 and No. 2 foundries are equipped with continuous sand handling systems. No. 3 foundry, which is light bench work, is worked from heaps cut back to benches with sand cutter.

6. Give some explanation of equipment used for sand processing.

Plant No. 1—We have four gasoline motor driven sand cutters, three sand slingers used as sand conditioners, and six portable type sand conditioners.

Plant No. 2—Heap sand is first put through aerator, after wetting, and then taken in boxes to facing mill where it is put through screen and falls on belt which carries it over magnet to remove metal. Sand falls into skip hoist where correct amount of new sand and sea coal is added. The measurement is volumetric. When one skip hoist has enough old sand, the old sand is run into another. The skip hoist raises sand in the two muller-type, pan mixers where southern and western bentonite and water are added. The finished facing goes into box which is transported by truck to the molding floor.

Plant No. 3 — For each wheelbarrow full of facing delivered to the molders, about ¾ of a wheelbarrow of his heap sand is brought back to the facing room, where it is dumped on a screen to remove any chills or particles of iron in the sand; and then about 70 per cent of this returned screened sand is dumped into lift bucket on the No. 1½ muller-type pan mixer, and to it is added new opener sand, new molding sand, southern bentonite, and sea coal according to the type of facing desired, and then mulled in the mill for 5 min., at which time it is properly tempered with water and then discharged through aerator attachment from outlet of mill into wheelbarrow, and then dispatched to molders needing it.

Plant No. 4—Heaps are cut nightly with a sandcutter. Floors having cores and chills are riddled. A muller-type, pan mixer is used for mulling facing sand.

Plant No. 5—Elevated from floor through rotary riddle, tempered, through paddle mill onto cooling belt, then through revivifier to distributing conveyor to molders' hoppers.

Plant No. 6—Riddles, pug mill, cooling belt and aerators.

Plant No. 7—Used sand is brought to floor grating, dumped at night and elevated to storage bins. Batch type preparation in two muller-type, pan mixers produces the required facing sands stored in overhead bins from which withdrawals are made by truck to the respective molding floors.

Plant No. 8—Sand reconditioned in muller-type, pan mixer after addition of illite-type clay.

Plant No. 9—Facing used on all patterns. Mixed in muller and put through aerator.

Plant No. 10—Spill and shakeout sand return to storage bins. This is then fed with new sand addition to mulling machines. After mulling, sand is delivered to hoppers above machines or slingers.

Plant No. 11—Return sand from the shaker to a dry sand storage bin, then mixed in sand muller, where clay, sea coal and water are added. A prepared sand bin holds some 50 tons. This prepared sand goes through an aerator and is carried on belts to conveyor lines where it is ploughed off into hoppers for use by the molders as may be required.

Plant No. 12—A muller-type, pan mixer for facing sands only.

Plant No. 13—Two 3000-lb. muller-type, pan mixers produce a facing-backing sand for a continuous slinger mold conveyor line, and a continuous hopper mold conveyor line (each a separate unit). One-third of plant operates by facing and heaps.

Plant No. 14—In No. 1 and No. 2 foundries, sand is supplied to molders in bins above their machines. Sand is mixed in a high speed muller and delivered by means of elevator to overhead conveyor belt and discharged into bins. Sand is fed to molds from bins through conventional clam shell spout.

7. Does plant have own sand control laboratory? If feasible, give some description of sand control equipment as to type.

Plant No. 1—We have our own sand control laboratory. Moisture teller, sand ramming apparatus, permeability apparatus and hand operated dead-weight type apparatus to determine compressive green and dry strength of molding sands.

Plant No. 2—The metallurgical laboratory takes sand tests. Equipment includes motor driven sand strength machine, permeability meter, sand rammer, moisture teller and bomb-type moisture tester. With the latter type apparatus, the moisture is determined by the pressure of acetylene gas on a pressure gauge calibrated in percentage moisture. Calcium carbide is added to the sample. We prefer this apparatus because of speed and convenience.

Plant No. 3—Yes. We use the green bond compression machine, permeability meter, bomb-type moisture tester and U. S. standard screens.

Plant No. 4—Yes. We use moisture teller, sand rammer, permeability meter and strength machine.

Plant No. 5 — Control moisture, permeability, green and dry shear, compression and fineness.

Plant No. 6—Foundry has sand control laboratory with proper equipment.

Plant No. 7—Sand control equipment available and utilized in part for sand control. Equipment consists of specimen rammer, permeability meter, moisture teller, strength machine.

Plant No. 8—Laboratory runs per-

meability, dry and green strength, moisture from samples taken from heaps, usually every other day. Additions are made as necessary to maintain required permeability and dry strength.

Plant No. 9—Yes. Moisture, permeability and green strength.

Plant No. 10—Foundry does have sand control laboratory. For green strength and permeability the usual equipment is used. For moisture determinations, a carbide determinator is used. A cement tester is used for core tensiles and a dilatometer is used for hot properties.

Plant No. 11—Yes. Moisture tester, bond-shear machine, permeability machine, muffle furnace, core baking oven, clay wash, core gas determinator.

Plant No. 12—We have sand control laboratory equipped as follows: moisture teller, sand rammer, core dryer, permeability meter, motor operated strength tester.

Plant No. 13—Yes. Moisture teller, bomb-type moisture tester, rammer mounted on wooden pedestal, permeability meter, strength machine, flowability meter, deformation meter, small oven for dry bond testing, and screen series and shaker.

Plant No. 14—We have sand control laboratory. Sand is checked every half hour for moisture, permeability, green compression, and deflection. Sieve tests are taken once a week, or oftener if necessary.

8. Does plant have specifications for buying sands? If so, give examples.

Plant No. 1—We purchase standard grades of natural bonded molding silica (washed) and Lake sands, common in this district which have proven satisfactory for our facings and heaps, taking into consideration the conditions our sand heaps retain by their additions.

Plant No. 2—The following are typical sand analysis:

	Sand, per cent		
Mesh	*Juniata Bank*	*Bonded Silica*	*Michigan City*
30	....	.....	.....
40	....	2	.....
50	1.1	33	.....
70	2.0	45	.....
100	37.2	17	.....
140	40.2	3	.....
200	17.6	.....	.....
270	1.5	.....	.....
Pan	0.4	.....	.....
Clay	0.8	None	.....
Grain Fineness	97	51	50–52
Base Permeability	45	155	.....

Plant No. 3—No, but are now in process of setting them up.

Plant No. 4—Sand is purchased by name and grade thus: South Y Heavy; Helmick No. 14; Silica sand 1F; Vassar bank sand. We make our own heap sand mixtures from above sands, adding fire clays for bond.

Plant No. 5—Specification calls for not over 8 per cent moisture in car. A.F.A. fineness number and clay content.

Plant No. 6—No natural molding sand bought; use synthetic molding sand.

Plant No. 7—Yes, but incomplete.

Plant No. 8—In our purchase of naturally bonded sands we try to secure a sand having the permeability needed with as high a bond as available, having in mind the heat resisting properties of the particular sand.

Plant No. 9—Do not have our own specifications. Buy from samples based on tests.

Plant No. 10—Plant has specifications for buying sand.

Bank Sand. The material desired is a sand that is suitable for use in making molds and cores.

(1) *Size.* Not less than 15 per cent, nor more than 45 per cent, should remain on the 70-100 mesh screens, balance through 100 mesh.

(2) *Chemical.* This sand should not contain less than 85 per cent SiO_2 (silica) and not more than 6 per cent Al_2O_3.

(3) *General.* This material must be clean, being free from quicksand, roots and all foreign matter.

(4) *Methods of Tests.* Tests will be made in accordance with the A.F.A. standard methods on the original lot furnished at the time contract is made. All subsequent shipments must be of equal or better quality.

Silica Sand. The material desired is a sand known to the foundry trade as a crude silica sand.

(1) The desire is to obtain as uniform rounded grain as possible. On a screen test not less than 80 per cent must remain on the 40 and 70 mesh screens, none remaining on the 10 mesh and not more than 10 per cent passing through a 100 mesh.

(2) *Chemical.* On analysis this sand should show not less than 95 per cent SiO_2 (silica) and not more than 1.5 per cent CaO plus MgO. A highly siliceous sand will be given preference.

(3) *General.* This material must be clean free from roots and all foreign matter.

(4) *Method of Test.* Tests will be made according to the A.F.A. standard methods on the original lot furnished at the time contract is made. All subsequent shipments to be of equal or better quality.

Plant No. 11—Bank Sand Specifications.

	Per Cent	
Screen No.	*Max.*	*Min.*
6	0.0	.....
12	0.0	.....
20	0.05	.....
40	1.5	.....
70	35.0	10.00
100	30.0	15.00
150	35.0	20.00
200	35.0	15.00
270	15.0	.....
Pan	0.5	.....

Chemical Composition. This sand shall have a colloidal content of less than 0.75 per cent and a total alkali content of less than 1.0 per cent; also, free of roots and other foreign material.

Sharp Sand Specifications.

	Per Cent	
Screen No.	*Max.*	*Min.*
6	0.00	.....
12	0.00	.....
20	0.50	.....
40	8.00	.....
70	.....	88.00
100	5.00	.....
150	0.50	.....
200	0.50	.....
270	0.30	.....
Pan	0.20	.....

Chemical Composition. The total colloidal matter plus alkali shall be less than 1 per cent. Sand shall be 98.0 per cent SiO_2.

Plant No. 12—We have sand specifications for purchasing. Some examples are:

Grain size No. 2
Class—D
Clay—9-10 per cent
Grain size No. 1
Class—E
Clay—15 per cent

Plant No. 13—Yes. Shirland and Berlin No. 2—A.F.A. fineness 72.

Plant No. 14—No. Molding sand is purchased as such. A large proportion of core work keeps system supplied.

9. Are specifications or standards available for sand as used in heaps or systems?

Plant No. 1—On the slinger floor we keep the moisture at 3.5-4 per

cent, compressive strength, 4-5 psi., and a permeability of 140-160. This is maintained by Lake sand additions with a colloidal clay, and the facing used has a moisture of 3 to 3.5 per cent, compressive strength, 9½-10 psi., and a permeability of 170-190. The heaps of sand used for medium castings have moisture of 4-5 per cent, a strength of 5-8 psi., depending upon the type of casting to be made, and a permeability of 70-120.

The lighter castings are made with Champion sand from heaps. The moisture is 3.5-4.5 per cent, strength, 3-5 psi., and permeability of 20-35.

Plant No. 2—Average facing sand mixture should run as follows:

Green bond, per cent	5.5 — 7.0
Sea coal, per cent	3.0 — 5.0
Permeability	120 — 140
Moisture, per cent	2.75 — 3.75

Plant No. 3—We endeavor to follow the specifications shown in Table 1 on the various types of facings as they come out of the mill. Raw sand analysis is shown in Table 2.

Plant No. 4—Records are kept of sand mixtures best suited for certain jobs, and sand heaps are built up to these standards.

Plant No. 5—Yes.

Plant No. 6—Yes, green strength, 7 to 8 psi., permeability, 80, moisture, 4 to 5 per cent.

Plant No. 7 — Specifications for sand mixtures are given.

Plant No. 8—No. All our sand is in heaps and treatment for each heap is made suitable for the job running at the time.

Plant No. 9—No.

Plant No. 10—For malleable castings having large amounts of cores the following specifications are used: Green strength, 9-12 psi. Permeability, 150-180. Moisture, 2.2-3.2 per cent. For smaller castings, permeability is 120-150.

Plant No. 11 — Malleable Sand System.

Moisture, per cent	4.4
Permeability	130
Bond, per cent	7.5
Sea coal, per cent	5
Dry strength, psi.	75
Fineness, A.F.A.	55-60
Clay Content, per cent	5
Shear, psi.	2.3

Plant No. 12—Yes. An example—moisture, 6 per cent; permeability, 50; green compression strength, 6.

Plant No. 13—Yes. A screen test is run once a week to aid in checking grain fineness of heaps against basic sand.

Plant No. 14 — No specifications written up.

10. How are sands checked, daily or periodically? Please give periods of checking.

Plant No. 1 — All facings are checked each day on an a.m. and p.m. basis, with many types checked as to each batch mixed. Certain sections of the heaps are checked each day as are special heaps.

Plant No. 2—A minimum of two tests for each 8-hr. shift are taken.

Plant No. 3 — Once or twice a week the various facings and several of the heaps are checked for permeability, green bond and moisture. If found to be coming outside of specified limits, slight changes are made in mixtures to bring them back.

Plant No. 4—Facing sand, every batch. Heap sand, nightly. Samples are taken from three points, at the two ends and center of heap.

Plant No. 5 — Daily. Complete test in a.m. and p.m.

Plant No. 6—Sands checked hourly.

Plant No. 7—Sands are checked on periodic schedule daily.

Plant No. 8—Usually every other day. Sample taken from three places in heap.

Plant No. 9—Each batch of facing sand is tested for moisture, permeability and green strength.

Plant No. 10—Molding sand is checked on each system every half hour. Core sand is checked daily for tensile properties and weekly for hot properties.

Plant No. 11—Every half hour for moisture, bond and permeability; once a day for sea coal and dry strengths. Fineness and clay content once a week. Shear, once an hour.

Plant No. 12—Checked weekly.

Plant No. 13 — Checked daily,

Table 1

MALLEABLE SAND MIXTURES‡

	Sand Mixtures			
	No. 1	*No. 2*	*No. 3*	*No. 4*
Castings	Light—Small	Medium	Heavy—Large	Extra Heavy—Extra Large
Section, in.	0 to ¼	¼ to ¾	¾ up	¾ up
Weight, lb.	0 to 1	1 to 10	10 to 50	50 up
Specifications				
Permeability	25±10 (31)*	45±15(35)*	60±15 (46)*	75±15 (62)*
Green Strength, psi.	6±1 (6.7)*	7±1 (8.7)*	8±1(8.9)*	8±1(8.3)*
Moisture, per cent	5±0.5(5.5)*	5±0.5(5.5)*	5.5±0.5(5.5)*	5.5±0.5(5.0)*
Sand Mixture, qt.				
Opener—Bank or Ottawa	40** Bank	40 Bank	40 Ottawa	80 Ottawa
New Nash or No. 2 King	24 Nash	24 King	24 No. 2 King	24 No. 2 King
Sea Coal, qt.	6	6	6	6
Binder, qt.	2	3	4	6
Old Heap,† qt.	221	221	221	178

*Numbers in parentheses are representative actuals.
**No. 8 scoop used averages 8 qt.
†To fill remainder of 300-qt. bucket.
‡Average of all four mixtures, percentage composition: Opener, 16.7; new, 8.0; sea coal, 2.0; southern bentonite, 1.3; old heap, 72.0.

Table 2

APPROXIMATE ANALYSIS OF RAW SANDS

	No. 2 King	*Vassar Bank*	*Nash*	*Ottawa*
Clay, per cent	22.8	0.4	17.4	Less than 2
A.F.A. Fineness	104	101	133	25 (approx.)
Permeability*	65	110	30	400+
Green Strength*, psi	7	0	6.2	0
Dry Strength*, psi	20	0	21.0	0
Sintering Point, ° F	2500	.....	.....	.....

*Moisture content, 6 per cent.

morning and afternoon by sand supervisor and assistant.

Plant No. 14—This was answered under No. 7.

11. What are considered essential fundamentals of your sand control work?

Plant No. 1—We consider it essential to our sand control work to keep our permeability and strength within limits. This is tied in very closely with metal and gating practice to eliminate shrinkage and cracks. Another feature in line with permeability is to use a special grade of sea coal which is somewhat coarser than that ordinarily used on heavy gray iron work. Whenever necessary we add pure lake sand to heaps for certain types of castings if previous jobs did require a finer sand. We also make use of the addition of a synthetic sand in addition to heaps of lake sand and clay to keep both strength and permeability.

Plant No. 2—Daily tests on the sand for green compression strength, permeability, moisture, and sea coal are considered essential.

Plant No. 3—(1) Periodic checks for desired specifications. (2) Following-up appearance of castings for smoothness attained. (3) Seeing that laborers do not sidetrack use of screen. (4) Endeavor as much as is practicable, to use old heap sand in making up the different mixtures from heaps on which that type of facing is used. (5) Measure sea coal and binder with containers for that purpose—*not with the scoop.*

Plant No. 4—The setting up of standards of moisture, permeability and strength for all jobs, and strict adherence to these standards, thus eliminating scrap losses due to unsuitably conditioned sand.

Plant No. 5—Keep within permeability limits, moisture control and bond.

Plant No. 6—Hourly checking for standards given in (9).

Plant No. 7—Hot strength of sand.

Plant No. 8—Proper strength to withstand duty in molding and permeability. Heat resisting properties.

Plant No. 9—Moisture, permeability and green strength held within limits prescribed for various classes of work.

Plant No. 10—Essential fundamentals in sand control work are: Green strength for control of hot tears; collapsibility of cores for control of cracks and hot tears; permeability for elimination of blows; and moisture control for eliminating dirt and blows.

Plant No. 11—(1) To control uniform quality of sand. (2) To help control casting defects due to sand troubles. (3) To carry out investigations.

Plant No. 12—Moisture and permeability.

Plant No. 13—A basic sand suited to the type of castings produced; moisture control, permeability control, strength control.

Plant No. 14—Permeability of over 80. Moisture, 5.0 per cent or under.

12. Give any special information as to sand control work in keeping with your policy.

Plant No. 1—The sand control work is followed very closely by a woman employee who makes reports daily to the furnace foreman and to the foundry management of sand and facings used on the first shift. We also have a foreman whose duties are only to watch and check all facings and heaps on the second and third shifts.

Plant No. 2—We consider sufficient mulling very important. Because of the time element our mulling time is about 3 min. We would prefer 5 min. if possible.

Plant No. 3—Much more attention even than we are now giving it will pay big dividends in reduction of scrap. At present, the shortage of proper type of laborers and semi-clerical subforeman type of supervision is a great handicap to better control and speedier progress.

Plant No. 4—No comment.

Plant No. 5—All our system sand is equivalent of facing sand.

Plant No. 6—Know of nothing special about our sand control work.

Plant No. 7—Study of behavior of sand mixtures used in respect to high temperature effects.

Plant No. 8—No comment.

Plant No. 9—No comment.

Plant No. 10—No comment.

Plant No. 11—(1) Inspect and test all incoming raw materials. (2) Investigate new products. (3) Maintain records of sand tests and investigations for future references. (4) Correlate scrap and sand troubles to minimize amount of scrap.

Plant No. 12—Control of dry strength is very important for malleable products.

Plant No. 13—In the control of molding sand, we are constantly aiming for the following: (1) To prepare a sand that can be easily worked by the molders and reduce molding losses to a minimum; (2) a sand that will produce castings free from cuts, blow holes, scabs, roughness, dirt and other defects; (3) a sand that will clean easily from the castings; (4) a sand that can be prepared for nominal cost.

Plant No. 14—Covered under other questions.

Discussion

W. A. KENNEDY[1] *(written discussion):* The replies to the questionnaire on "Malleable Sand Control" serve to emphasize the complexity of a problem which is of vital importance in the operation of a modern foundry. Quite logically and rather definitely the indications are that it is economically impractical to consider any move leading to the standardization on one grade or type of sand, with the result that the various foundries start off with a wide range of variable factors which have direct bearing on the important questions of bond, permeability, and fusibility.

The replies indicate that the importance of adequate bond and permeability are generally recognized, and there is a gratifying indication that up-to-date testing devices and plant operating procedures are being employed for periodically checking both of these points. Only two of the foundries mention refractoriness or hot strength of the mixture as being subject to follow-up control. Possibly this matter was slighted in filling out the questionnaire and is being given more consideration than is indicated by the replies, but if not it may be something which can properly receive more general consideration. It seems probable that this is a point which will be discussed at some length in one or more of the papers which are now being prepared.

Question No. 4 brings up a problem which may warrant some study with the ultimate end in view of setting up some practical working standards. For instance, a set of photographs might be selected as representing a number of commercially acceptable finishes ranging from "fine" to "coarse," the coarse grade to be set at a limit which would be acceptable under conditions such as those which would hold for Plant No. 10 but still be in line with reasonably good practice from an industrial angle. If this were to be done, the Association would then be in position to issue a strip of half-tones showing at full size or at ordinary reading glass magnifications an acceptable definition of a range which

[1]Supervisor of Products, Grinnell Co., Providence, R. I.

could include divisions such as (1) "fine-special," (2) "fine," (3) "medium," (4) "coarse," (5) "coarse-maximum." Certainly it is hard to believe that the terms fine, medium, and coarse which appear in the replies are based on an adequately defined grading. Yet finish is an important requirement for many products.

The answers to Questions 7 to 12 show that the importance of sand control is uniformly recognized and that standard equipment is in general use. This affords a good background for the development of a comprehensive coverage of average working requirements and ability to reasonably define results which an organization may expect to obtain. The reply from Plant No. 3 is unusually complete. It presents the facts so clearly and concisely that it is probable some worth-while comparisons and useful information would be obtained if the other foundries were to be requested to fill out a follow-up questionnaire which would be based on No. 3's coverage. Doubtless all of the foundries are not in position to give as much detail, but probably such a questionnaire would produce additional facts which would be of assistance in classifying the practices as developed to date.

R. W. LINDSAY[2] *(written discussion):* The answers to the first three questions of the questionnaire give a good idea of the type of work being handled in malleable foundries both as to size and applications of the castings. Obviously the finish on these castings varies, but in most instances it tends to run to the medium or fine. The tendency seems to be for jobbing work to be turned out to a finer finish, but this depends to a large extent on the nature of the work. The natural extremes are the work produced by No. 10 such as housings and the like where finish would be a secondary factor as in comparison to the small castings of the type made by No. 1 in which finish would be more important.

Although the details apparently differ, the general principles on sand processing seem to be the same. The plants appear to be about evenly divided between the use of heaps and continuous sand handling systems. Facing sands are prepared by mulling shakeout sand with new sand, bond, sea coal and water. The ample use of sand testing and control equipment is noted to be common to all plants. A more or less representative layout includes: Moisture tester, permeability apparatus, strength machine (green and dry strength), specimen rammer, screen series and shaker (grain distribution and fineness).

Other tests mentioned in isolated instances were hot property tests employing a dilatometer and the determination of deformation and flowability characteristics.

Most of the plants attempt to set up some type of specification for buying their sand. There appears to be a good deal of divergence in this respect. Although each plant has its own reasons, no doubt, for their choice of specifications, that stated by Plant No. 10 appeared to be concise and to cover the purchasing of this important raw material rather thoroughly.

Again each plant must have its own ideas for the sand standards they are employing for their heaps or systems. However, the thoroughness of Plant No. 3 and Plant No. 11 might yield the best results in the long run. It would seem that adherence to such standards plus the keeping of close records against casting yield or quality would pay good dividends. The value of close checking of the standards they have set up appears to be recognized by all plants answering the questionnaire. This is emphasized by most answers to Question 11. The answer from Plant No. 10 to this question appears to sum up the essential fundamentals of sand control work in good general fashion thus:

Control of strength for control of hot tears.

Collapsibility of cores for control of cracks and hot tears.

Permeability for elimination of blows.

Moisture control for eliminating dirt and blows.

Some of the answers given to the final question (No. 12) regarding sand control work were especially pertinent. A consideration and combination of the answers from Plants No. 3, 11 and 13 would probably form as good a summary as any for the aim of all foundries in their sand control.

R. J. ANDERSON[3] *(written discussion):* We find that the summary on "Malleable Foundry Sand Control" contains valuable information as to what other malleable foundries are doing along the line of sand control. Particularly noticeable is the importance that is being attached to sand control by other foundrymen.

We consider sand control to be a vital factor in the production of good castings in our plant. In the past year two continuous sand handling systems have been installed, and this has been a great aid in achieving closer sand control. This installation also brought to light the need for closer supervision on sand.

We believe that we have a fair arrangement for sand control in our malleable foundry, and expect to improve this considerably by the establishment of a sand control and experimental laboratory, which is included in our present building program.

[2]Assistant Professor of Metallurgy, Pennsylvania State College, State College, Pa.

[3]Works Manager, Belle City Malleable Iron Co., Racine, Wis.

APPRENTICE CONTEST

Prints and Patterns Now Available

CONTESTS for apprentices will be held in 1946, as in the past, according to the Apprentice Contest Committee. Expecting greater participation than in any previous year, the committee met recently to select the patterns and blueprints to be used by the contestants. The members of the Apprentice Contest Committee are: Chairman, George Zabel, Universal Foundry Co., Oshkosh, Wis.; Frank C. Cech, Cleveland Trade School, Cleveland; Jas. G. Goldie, Cleveland Trade School, Cleveland; E. P. Meyer, Chain Belt Co., Milwaukee; C. W. Morisette, Milwaukee Vocational School, Milwaukee, and C. W. Wade, Caterpillar Tractor Co., Peoria, Ill.

Patterns for the molding contests and blueprints for the pattern contest have been prepared and are available through the National Office, 222 West Adams Street, Chicago 6. In accordance with regulations governing the contests, patterns and blueprints may not be seen by the contestants until the start of the competition.

Prizes of $30, $20, and $10, plus a certificate recognizing the award, are given to the three winners of each division of the National Apprentice Contest. Awards are made for pattern-making, gray iron, steel, and non-ferrous molding.

A single company may enter one contestant in each division of the Apprentice Contest, the entries being selected on the basis of a local competition in the plant. If several foundries, or an A. F. A. chapter, conduct a local contest, three entries may be made in each division in the National Apprentice Contest.

In addition to the cash awards, first prize winners of the four divisions will be brought to Cleveland to be honored at the 50th Anniversary Convention. This innovation necessitates judging the National Apprentice Contest several weeks before May 6, 1946.

Recognizing that many apprentices are former servicemen, the Apprentice Contest Committee has changed the age limit for contestants. Formerly limited to indentured apprentices who had not reached 24 years of age on the date they enter the contest, the competition is open now to servicemen who are not older than 24 plus the time they have spent in the armed forces.

Cleanliness and Safety in the Foundry

By James Thomson, Chief Works Engineer,
Continental Foundry & Machine Co., East Chicago, Ind.

• Foundry cleanliness—its importance in promoting safety and in effecting foundry operating economies—prompts the presentation of this article, originally published in "Safety Engineering," Sept., 1944, issue.

IN THE face of a serious manpower shortage, the need for continued study and improvement of foundry practice becomes a matter of utmost consequence. In order to maintain production at high efficiency, operations which may be responsible for flawed or faulty castings must be weeded out and carefully scrutinized for means of improving them.

In realization of these facts, a survey was made of this foundry to reveal those operations which could be considered of questionable efficiency, and where improvement would have a beneficial effect on production, either by reducing or eliminating rejected castings, or by better utilization of manpower.

Back Where They Started

One operation which attracted immediate attention was the practice of cleaning sand molds by compressed air. Although this method of mold cleaning has been common practice in foundries, it did not require much observation to recognize its shortcomings.

Instead of cleaning the mold, the compressed air stream would scatter the dust particles in all directions. The lighter and finer dust particles were picked up by air currents and carried throughout the plant. The heavier dust particles rapidly settled, only too frequently settling back onto the "cleaned" mold from which they had been blown off, or onto adjacent molds which had previously been blown clean.

Fig. 1—Suction cleaning of large molds.

Large open molds, particularly those having deep and intricate patterns, presented a special problem, because disturbed dust would settle into the deeper cavities of the mold without being readily noticeable. As the operation of blowing molds clean would continue from mold to mold, dust would continue to accumulate in the already cleaned molds, penetrating into the deepest portions.

It was apparent that castings of fine appearance, and smooth, uniform surfaces could not be assured if metal were poured into molds thus "cleaned." A more positive and effective method of cleaning molds was required, and to accomplish this a heavy duty pneumatic

Fig. 2—(left) Smaller mold being cleaned by suction hose.

Fig. 3—(right) Vacuum removal of steel shot from casting cavities after shot cleaning.

cleaning system was installed in the No. 3 foundry.

This system, which is a stationary type of unit, consists principally of a multi-stage centrifugal vacuum producer driven by a 50-hp. motor connected to it by a flexible coupling, a 48-in. diameter combination dust separator of the inverted filter bag type, and three 18-in. diameter primary shot separators. All of the separators have cone hopper bottoms fitted with hinged dust disposal valves.

Vacuum Cleaning a Foundry

The piping system consists principally of three vacuum mains. The longest is 775 ft. in length and extends through the foundry building. The remaining mains are 500 ft. and 150 ft. in length. All three mains run well overhead and out of the way. Drops extend down at strategic points to provide vacuum cleaning connections for the working area of the building.

These drops are spaced so as to permit the area to be adequately reached using convenient lengths of hose. As much as 75 ft. of 1½-in. hose is used. Each drop is terminated with a vacuum hose inlet valve which closes automatically when the hose is withdrawn. As many as ten operators may use this system simultaneously at different areas in the foundry.

With this system, molds are now cleaned by suction. Slender lance-type nozzles, available in lengths up to 6 ft., are used to penetrate deep into the mold design, reaching all surfaces and removing all dust and loose material. Gulper nozzles are used for cleaning molds which have large flat surfaces. For smaller molds, the open end of the hose is used effectively without a nozzle (Figs. 1 and 2).

Cleaning Molds

Dust and foreign matter are drawn rapidly into the vacuum nozzle, conveyed through the hose and piping system to the dust separator where the dust is filtered out of the air and the cleaned air then passes through the vacuum producer and is exhausted into the atmosphere.

Many advantages have been obtained by using vacuum for doing this work. The most important gain, of course, has been the more thorough cleaning of the molds. In addition, there has been a marked improvement in the condition of the plant atmosphere, which no longer is periodically recharged with dust. This cleaner atmosphere not only provides better visibility for the operator, but enables him to work under more healthful conditions.

Fig. 4—Another example of steel shot removal from large casting.

Removing Shot

Another interesting and time-saving operation now being done by vacuum is that of removing steel shot from pockets in castings after the castings have been shot cleaned. Removing shot from cavities in castings has always been a slow and time-consuming task, particularly if the shot were lodged in hard-to-reach pockets and corners. Using vacuum, all pockets are thoroughly and rapidly cleaned of shot accumulations (Figs. 3 and 4).

Not only has this application proved a valuable time-saving device, but it has resulted in the recovery of thousands of pounds of shot which otherwise might have been lost.

Special intercepting separators are provided for each of three shot blasting rooms. All shot collected in the area around the shot blasting rooms is intercepted and retained in the separator serving that shot blasting room.

The intercepting separators are designed to allow fine dust and other material to pass through them and to retain only the shot. All dust and other dirt passes through the intercepting separator and is conveyed to the 48-in. combination separator. Other material picked up by the system, as in mold cleaning, also is conveyed to the 48-in. combination which filters the air before it passes through the vacuum producer into the atmosphere.

The same system also is used for general cleaning in the plant, for removing overhead dust accumulations, for cleaning in and around equipment, and for removing all sorts of dust accumulations from floors. Special nozzles are provided for these varied operations. Many other useful applications have been encountered as the system is used.

The installation of this system was the result of satisfactory experience with a smaller 20-hp. system which was installed a number of years back in the No. 1 foundry for somewhat similar operations, but, of course, on a smaller scale.

Not only have these heavy duty vacuum cleaning systems increased the efficiency of many operations, but they have also improved working conditions and brought about appreciable economies by recovering valuable materials.

Acknowledgment

The author wishes to acknowledge the courtesy of United States Hoffman Machinery Corp., Syracuse, N. Y., in furnishing the illustrations.

Some Aspects of
GREEN DEFORMATION and SAND TOUGHNESS
In Sand Control

By Wm. G. Parker,
Metallurgical Dept., Elmira Foundry Co.,
Elmira, N. Y.

SAND control work, like other phases of foundry technology, should consider every advantage if the greatest amount of good is to be derived. It is the general practice among foundrymen who incorporate sand testing in their procedures to check the green compression strength, permeability and moisture. These all have importance in their own right. However, the green deformation test, when properly made and interpreted, can be of equal importance.

Although the deformation test is an important one, it is not used frequently, possibly because it needs special apparatus and involves some extra work. Furthermore, its bearing is not always understood.

It is agreed by foundrymen who have devoted any appreciable time to testing, that this test should be given greater attention in sand control work. Like any other test, the equipment used requires careful thought and manipulation. However, the amount of extra work necessary in setting the deformation attachment is very little. The actual procedure, as used by the author, will be described later in this paper.

Reducing Defects

Deformation is a sand characteristic which will not do the greatest amount of good unless other factors, such as the type of sand, type of bond, condition of preparation, moisture content, etc., are considered. When all these factors are taken into consideration, it becomes an extremely useful and important test and a definite aid in reducing defects in a foundry.

Opinions differ among operators regarding the factors which affect deformation and the interpretation of test results. R. Chadwick[1] states, "Molding sand, like other materials,

• Deformation and sand toughness number determinations provide the foundryman with important tools — too seldom used — for molding sand mixing efficiency and workability control — these factors directly affecting the amount of foundry scrap and machining time.

may possess sand strength but the strength is considerably limited due to a property which might be termed deformation." This writer firmly believes that if foundrymen were not so callous as to believe strength alone to be a deciding factor, much good could be derived by making application and endeavoring to secure correct interpretation.

The writer has long been interested in two properties of sand, namely, deformation and toughness. In his sand testing work, he found quite frequently that, in using the deformation attachment as supplied by the manufacturer, a "following along" with the arm of the machine as the deformation occurred, gave erratic results.

Test Apparatus Modification

To obtain results that check closely, he made certain modifications in the commercial apparatus commonly employed. These are shown in Figs. 1, 2 and 3.

The deformation test is made on the commercial motor-driven, sand strength machine at the same time that the sand specimen is tested for green compression strength. After placing the 2-in. A.F.A. standard specimen between the lower test heads, the deformation arm is lowered, making contact with the weight arm. Load is then applied on pusher arm by starting motor and running only long enough to show 1 psi. compression strength on the green strength scale.

This takes up all slack between

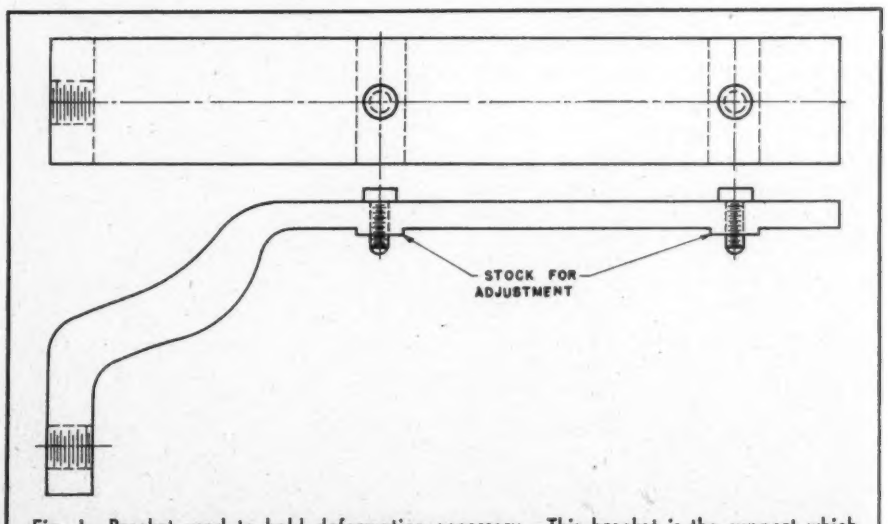


Fig. 1—Bracket used to hold deformation accessory. This bracket is the support which holds the deformation accessory independent of the holding weight shaft. Before drilling and tapping the two threaded holes in the head of the machine, make certain that the alignment or swing of the arm is equidistant throughout the travel on the arc of the machine.

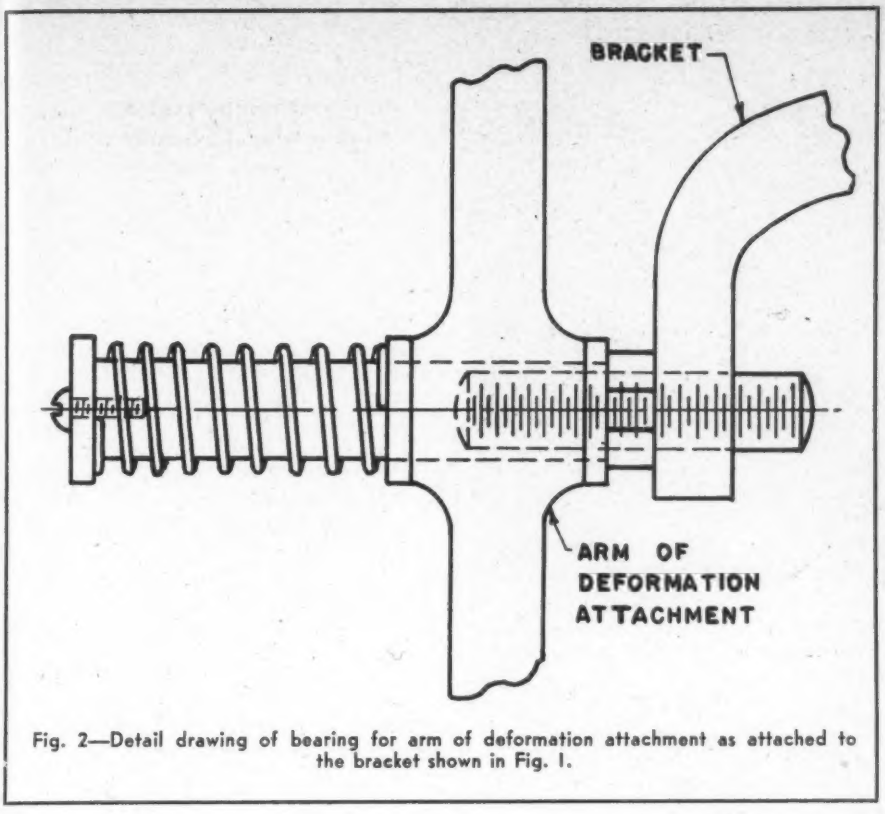


Fig. 2—Detail drawing of bearing for arm of deformation attachment as attached to the bracket shown in Fig. 1.

pusher arm and weight, making good contact between the sand specimen and test heads. At this point, the bezel dial on the deformation indicator is set at zero with the black hand; the red maximum hand is set against the indicator hand. Proper tension on the indicator shows a constant movement on indicator hand throughout deformation of the specimen. Failure of the hand to keep traveling while pressure is exerted, is due to lack of resistance at the indicator where contact is made on the arc of the machine.

To eliminate the parallel travel which the writer experienced in his testing, he made certain modifications in the present test apparatus. A separate bearing (Fig. 2) was attached to the topmost part of the machine, freeing the deformation attachment from the movable arm originally designed for attachment of the deformation accessory. An actual photograph of a machine with this modification is shown in Fig. 4.

Figures 2 and 4 show a brake shoe with an adjustable feature which allows the proper tension to be applied to the assembly to arrest the motion of the arm while performing the test. With these changes in the testing apparatus, we have been able to measure deformation of the sands used in our foundry consistently.

Figures 3 and 5 show the adjustable tension stop located at the end of the deformation accessory which rides on the steel arc of the testing machine immediately above the gear. The author designed this attachment to eliminate the "following along" experienced with the commercial set-up encountered when making the deformation test, and which was responsible for the erratic results obtained.

Deformation is expressed by the author in thousandths of an inch per 2 inches. (The recognized method of expressing deformation is inches per inch.) It is measured by means of the attachment to the compression strength testing machine.

If the deformation obtained on the sand is multiplied by the green compressive strength and the product multiplied by 1000, the figure obtained will express what is known as toughness of the sand, and the number itself is the sand toughness number. This number formerly was referred to as resilience. The late Professor A. C. Davis, Cornell University, called attention to the fact that resilience was an incorrect term and showed that toughness was the correct one.

What Deformation and Toughness Show. There seems to be a prevalent opinion held by those who have given much thought to the matter that deformation indicates the efficiency with which a molding sand has been mixed, that is, mixing efficiency. Many operators who determine deformation do not take the trouble to calculate the sand toughness number. However, in the opinion of the writer, the sand toughness number is an indication of the workability of the sand. Workability might be defined as the ease with which a molding sand can be formed into a mold of the required properties.

Molding Sand Plasticity

Buchanan[2] seems to feel that plasticity, which is necessary in a molding sand, is not in any way measured by the compressive strength test. In the writer's opinion, the deformation of a foundry molding sand determines: (1) the ease with which the pattern may be drawn from a mold and (2) the degree of accuracy of the mold cavity. Should either of these difficulties be encountered, the first obviously slows down production and the second either reduces the number of good castings pro-

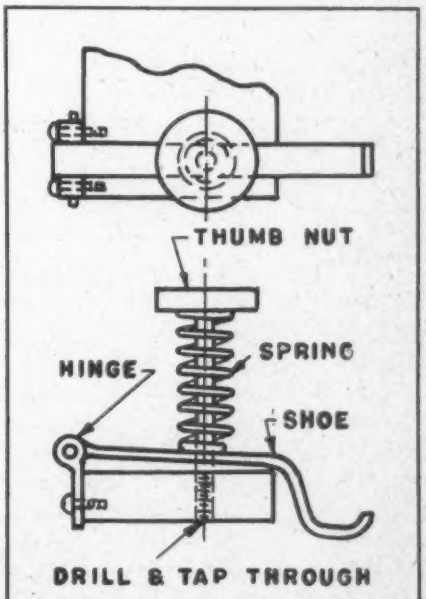


Fig. 3—Adjustable tension stop. This adjustable tension stop is located at the dial end of the deformation accessory and is held as shown. The shoe rides on the steel arc of the machine immediately above the gear.

This paper was secured as part of the 1945 "Year-'Round" Foundry Congress and is sponsored by the Committee on Deformation, Foundry Sand Research Project, Technical Development Program of A.F.A.

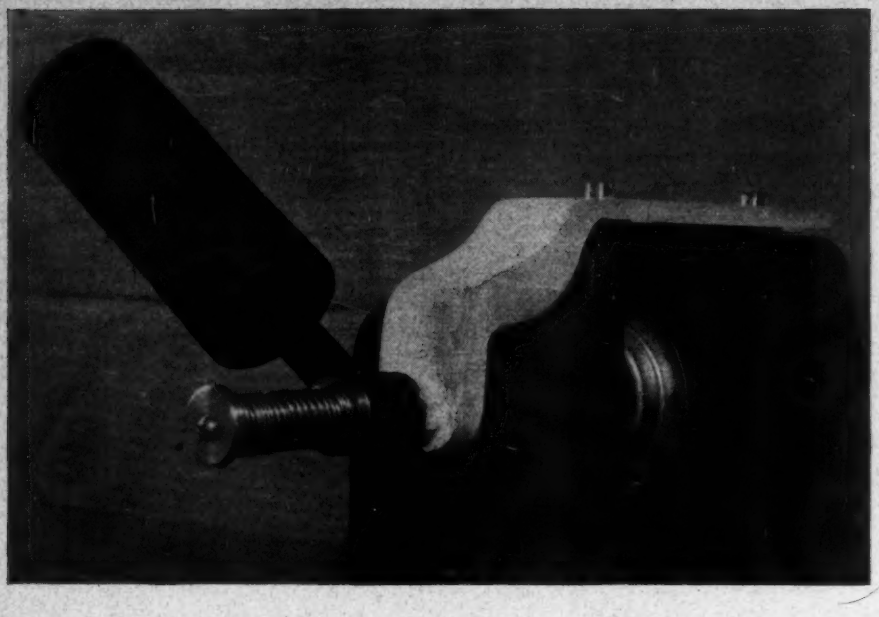


Fig. 4—Illustration showing the installation of the bracket and bearing at the top of a commercial, motor-driven sand testing machine.

duced or increases machining time.

Deformation vs. Green Strength. Deformation does not necessarily change in a constant ratio with green compression strength. Some binding materials give greater green compression strengths than others. This being true, it can be seen readily that, to get the same strength with different bonds, varying quantities must be used, providing everything else is equal.

Deformation and green strength are factors resulting from binding material additions. Some bonds possess greater plasticity than others. We have found this to be true by trials. Therefore, we have used varying percentages of different binding materials to get the desired results.

Two sands might differ in their green compression strengths, yet show the same deformation, or they might have same toughness number even though they varied in both green compression strength and deformation.

Examples. In our work, we have a number of different sand mixtures employing new sands which range in A.F.A. grain fineness from 145 to 45. Although these sand mixtures may have like characteristics in some of the physical tests, one sand would not supplement the other for best usage.

As an example, we mention the two cases shown in Table 1. Case 1 shows that, under *A*, we have sand which has only one-half the deformation value of that shown under *B*. This would indicate insofar as green compression strengths are unlike and moistures are nearly alike, that there must be a difference in sand grain sizes or the actual bond used. Case 1 also shows the same permeability in both *A* and *B*. This eliminates grain size. The most plausible answer would be the amount or the kind of bond used.

Mixing time and equipment all play a very important part in getting full value from bond additions. We may assume that sand *B* shows proper mulling and *A* shows that we have much unused bond still in our mixture. In Case 2, *C* and *D* represent the same sand with a variation of moisture content. This difference of 0.9 per cent moisture gives a green compression strength difference of 1.7 psi. and a difference in deformation of 0.003 in. in 2 in. The sand toughness number is the same in both *C* and *D*.

Effect of Changes in Sand Mixtures. The deformation of a green sand will vary depending upon changes in the ingredients of the sand mixture.

To understand these changes, which the different ingredients might have, it is necessary to understand the reaction of each not only individually but in combination with each other. It has been found that these changes do not give parallel lines on a graph. For this reason, when establishing a synthetic sand, it is necessary to consider grain size and distribution, bonding and glaz-

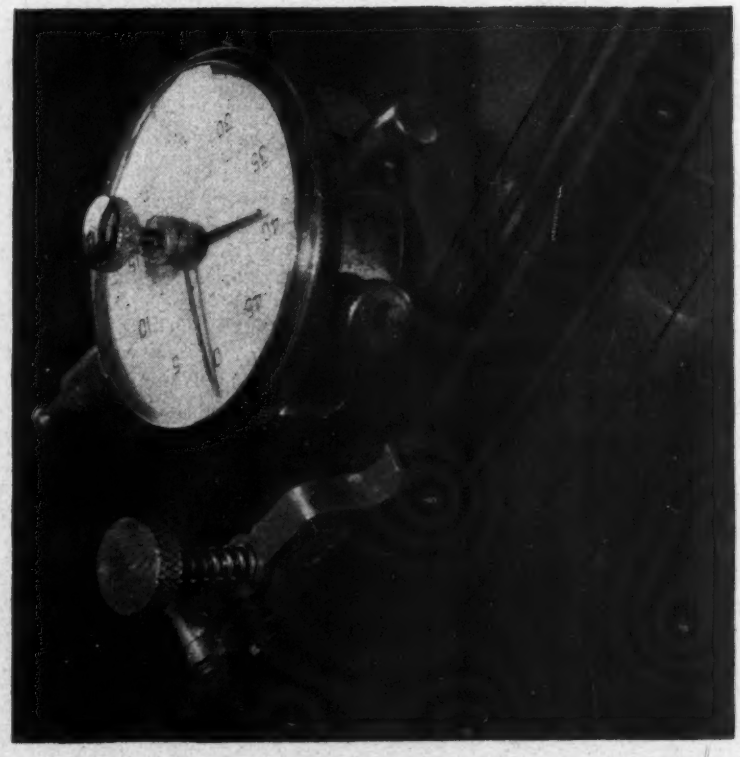


Fig. 5—Illustration showing the adjustable tension stop detailed in Fig. 3 attached to the arc of the machine.

Table 1

SAND PHYSICAL PROPERTIES

Sand	Moisture, per cent	Green Compression Strength, psi.	Green Permeability	Deformation, in. in 2-in.	Sand Toughness Numbers
		CASE 1			
A	4.1	8.1	150	0.015	121
B	4.2	7.3	150	0.030	319
		CASE 2			
C	5.5	9.4	25	0.014	131
D	6.6	7.7	24	0.017	131

ing materials, mulling time and moisture content.

Deformation vs. Sea Coal. There seems to be a difference of opinion as to the effect of sea coal on deformation. Chadwick[1] states that its addition makes the sand-clay mix short and brittle, while the bond strength increases. Dietert[3] states that toughness and deformation increase up to a certain point beyond which both decrease as more coal is added.

Deformation vs. Other Sand Properties. Other properties of a molding sand having definite effects on deformation and their correlation are not discussed here.

Sand Toughness

As previously stated, sand toughness is directly related to deformation. H. W. Dietert and E. E. Woodliff[3] have stated that ". . . resilience (toughness) values are in reality the true working strengths of a molding sand." It has been stated further that the terms "resilience," "workability," and "sand toughness" all express the same sand characteristics. It is the writer's opinion that the sand toughness numbers are the indication of the workability of a sand and that by their use, sand control can be simplified.

Effect of Changes in Sand Mixtures on Toughness. Increasing bond tends to make sand toughness numbers rise. Flowability also decreases, which makes the sand harder to ram and, as a result, requires a longer time to accomplish the ramming work. Likewise, the converse of this is true.

The optimum sand toughness number required in a given foundry will be dependent upon the materials at hand, preparation equipment available and the type of castings made. The leeway between toughness numbers is relatively small. We have found in our foundry operations that it is not necessary to be too cut and dried in considering this tolerance.

As an example, take two sands with a toughness number of 150. One sand may be used in a mold which is to be filled with metal which has a minimum pouring temperature and will result in a good finish on the casting. The other sand, having the same toughness number, may be prepared with less refractory materials, with an inferior bond and be poured with much hotter metal. Such a combination would not stand up to give a satisfactory casting.

Toughness vs. Permeability. With increasing sand toughness numbers, there is usually a decrease in permeability, because more moisture or bond has been added.

It is advantageous to keep the bonding material within safe working limits in using this expedient for control work. There is objection to using bond to increase the over-all sand toughness number. However, additional bond works against the purpose for which it is added, unless the mulling equipment and operat-

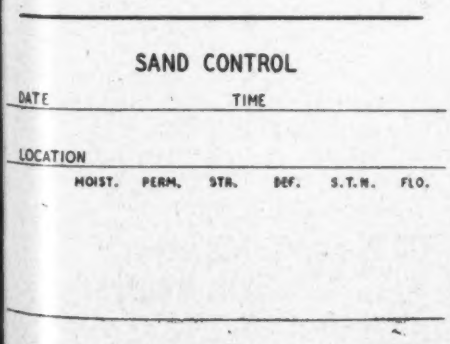


Fig. 6—Chart used to report properties of mulled batches to operators.

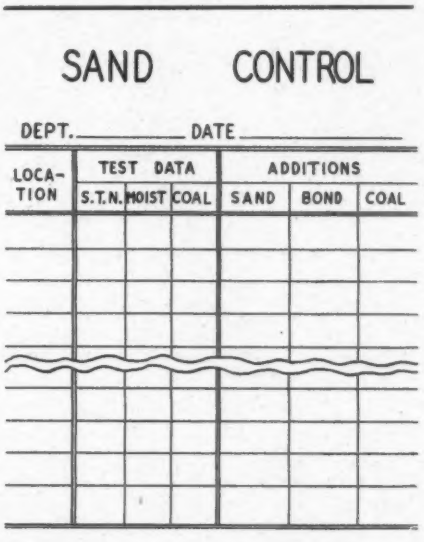


Fig. 7—Form used to show additions to be made to sand, separate floors and facings.

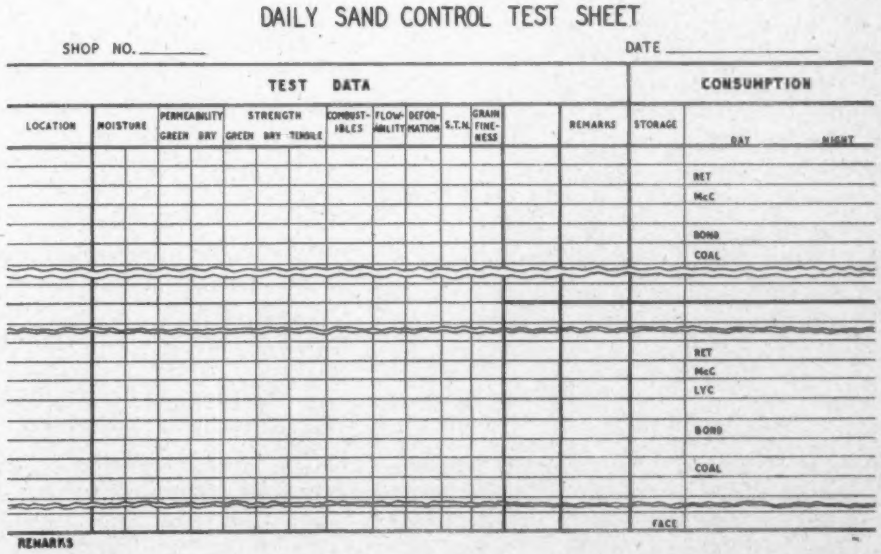


Fig. 8—Chart used to compile complete daily sand testing data. This form is kept on file.

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

ing procedures are such that no free bond is present after preparation.

Toughness vs. Grain Size. Other things equal, the smaller the grain size, the greater the sand toughness number. It is only necessary to understand that with the finer sands greater areas are exposed, thus making them more vulnerable to the bond material.

Toughness vs. Defects. A chart[4] is available showing relation of the sand toughness numbers to different mixtures as follows:

Ferrous and non-ferrous sands with sea coal	60-130
Gray iron and malleable sands with sea coal	70-130
Clay, bentonite, cereal bonded steel green sands	80-170
Skin or oven dried molds, steel sands	150-230

Above the upper limits of each group, there may be danger of scabs, buckles, or blows; while below the lower limits, there is danger of cutting, drops, rat tails, and mold peeling.

Sand control in any foundry can be expected to produce results, namely, decrease the number of defective castings, improve finish and shakeout conditions which reduce lumping of sand to a minimum, and improve the speed of production and accuracy of the castings, only if proper records are kept and used.

Records are of no value unless they are studied for trends, with the idea in mind of avoiding difficulties before they happen and by correlating them with conditions that obtain in the foundry. The company with which the author is associated believes also that there is a certain psychological advantage in the use of records from the sand preparation point to the final testing. As a result, it has devised the test sheets shown in Figs. 6, 7 and 8.

Figure 6 shows the form used to report the properties of the sand to mixer operators on mechanical sand systems. Figure 7 shows the form used to show the necessary additions to be made to sand on separate floors and those required for facings. Figure 8 shows the complete record sheet which is kept on file for future reference and records all test data for a given day.

It should be noted that on all sheets, sand toughness number (S.T.N.) is required and given, and that on the forms shown in Figs. 6 and 8, deformation also must be recorded. These facts indicate the belief of the author's company in the usefulness of deformation and sand toughness data.

The writer believes that every defect relative to casting finish hinges on a better understanding of sand toughness and deformation qualities. Sand toughness numbers can be the short-cut in sand control where plasticity and green compression strength are considered. Through the use of these numbers, once established, the true significance of control can be greatly simplified.

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2. Wm. T. Buchanan, "Sand Testing with Special Reference to Deformation," *Foundry Trade Journal,* vol. 62, no. 1230, March 14, 1940, pp. 199-202.
3. H. W. Dietert and E. E. Woodliff, "Measure Deformation of Molding Sand," *The Foundry,* vol. 67, no. 9, Sept., 1939, pp. 28, 29, 70.
4. H. W. Dietert Co., Detroit.

Gray Iron Committee Chairmen at Meeting

CHAIRMEN of committees of the A.F.A. Gray Iron Division met at the Statler Hotel, Cleveland, November 8. At this meeting a number of suggestions were made and some new committees were proposed.

The Committee on Pig Iron Qualities organized a group to work with ASTM and the American Iron & Steel Institute in their classification for pig iron on the basis of purchase specifications by the consumer.

Division Chairman T. E. Eagan, The Cooper-Bessemer Co., Grove City, Pa., discussed with the committee inquiries regarding specifications for surface finish and dimensional tolerances on castings. These inquiries were turned over to the Advisory Committee for further investigation.

It was suggested that a committee on gating and risering be formed for the purpose of accumulating information and the dissemination of information from a central point.

The formation of a committee on heat treatment of gray cast iron was proposed whose purpose would be to study carefully the heat treatment of cast iron in general and make recommendations for the heat treatment of various types of irons. It would also be the function of the committee to keep up with the new developments in the heat treating field and to review those every year at the annual convention.

For the purpose of studying methods of cleaning gray iron castings, with a view to improving methods, the Steering Committee proposed that a committee on cleaning gray iron castings be formed.

Foundry Personnel Survey Being Conducted by A.F.A.

THE Technical Development Program of A.F.A. is conducting a foundry personnel survey to determine the manpower needs in the castings industry. Expected to be of value in two different ways, the formation will be used in the National Educational Program to show young men the types and number of jobs available, and to demonstrate to educational institutions that there is a need to train men for the foundry industry.

Questionnaires were sent to all known foundries in Canada and United States. Emphasizing the significance of the manpower problem, there has been an unusually hearty response to the survey. A.F.A. appreciates this and also the letters of encouragement which have accompanied some of the returned questionnaires. It is hoped that foundries which have not returned their forms yet will do so at an early date so that the results of the survey can be published soon in AMERICAN FOUNDRYMAN.

GE X-ray Celebrates Fiftieth Anniversary

GENERAL Electric X-ray Corp., Chicago, recently celebrated 50 years industrial x-ray progress.

REFRACTORIES *for Electric Melting in the* FERROUS FOUNDRY

By E. K. Pryor and L. R. Burke, The Charles Taylor Sons Co., Cincinnati

REFRACTORIES in electric melting operations probably receive more severe abuse than in any other service. Replacement is always a matter of weeks. Unfortunately, it appears most likely that refractories will always have a relatively short life in such service. This limitation is imposed by the very nature of the operation. The extreme temperatures involved not only mean greater slag and flux activity but also tax the heat-resisting qualities of refractories to the utmost.

Electric furnace design features also place a handicap on refractories. For efficient operation the furnace volume, above that occupied by the charge, must be kept to a minimum. The result is a relatively small area for dissipation of heat. Only small design changes are permissible without seriously disturbing the efficiency of the melting unit. Such changes are being made when possible and as the value of the change is recognized.

Refractory Improvements

This does not mean that we have reached the service limit for refractories in electric melting operations. Manufacturers of refractories are constantly striving to improve their product. Improvements have not been spectacular but the progress has been steady. If a service comparison of a brick made 10 years ago were made against the same brand as made today, the results would be remarkably favorable to the latter.

Manufacturers are definitely limited by the known available raw materials. Most progress must be made through improvement of the physical properties. The approach in such effort is ably described by Birch*.

The operator of electric melting units can play a part in improving the service he obtains from refractories. In some instances, by observing a few precautions in operations, a great increase in refractory life is possible.

Refractory Failure

In electric melting refractories fail, principally, for the following reasons:

1. Chemical attack by fluxes, dusts and slags.
2. Erosion by slags, molten metal and charge.
3. Spalling; thermal, structural and mechanical.
4. Insufficient refractoriness.
5. Mechanical abuse.
6. Insufficient hot strength.

Almost always each of the foregoing factors will contribute to the ultimate failure of every furnace lining. The degree will vary greatly with the type of operation and the kind of refractory used.

Chemical attack or corrosion will vary in degree depending upon the following factors:

a. Compositions of the refractory and the fluxing or slagging agents.

b. Fluidity of the reaction products.

c. Temperature of furnace.

d. Temperature difference between hot and cold face of the refractory.

Refractories usually are placed in three categories; acid, basic, and neutral.

For electric melting operations, the following refractories are acid:

Fire Clay	Sillimanite
High Alumina	Zircon
Kaolin	Silica

There are those who would imply neutral properties for high alumina refractories containing over 60 per cent alumina, and for sillimanite type refractories. It is true that they will resist basic slags and fluxes better than materials of lower alumina content, but essentially any of these products will react acid in the presence of strong bases and similarly will react basic in the presence of strong acids.

Properties of Silica

Silica will withstand the action of iron oxides alone better than the alumino-silica refractories, fire clay, high alumina, kaolin and sillimanite. The fusion points of these materials are lowered markedly by small amounts of iron oxides, whereas the fusion point of silica is not materially lowered until the iron oxide concentration approaches 40 per cent.

Similarly, silica will withstand the attack of lime without much damage until the lime concentration reaches 27 per cent. Silica will probably withstand the attack of fluxes and dust in the furnace atmosphere as well as any of the foregoing but, where temperatures exceed its soften-

*R. E. Birch, "Phase Equilibrium Data in the Manufacture of Refractories," *Journal*, American Ceramic Society, vol. 24, no. 9, Sept., 1941.

• ***Electric melting imposes severe refractory service conditions. Progress has been steady in refractory manufacture, particularly in physical property improvements. A few simple precautions observed in electric furnace operation will prolong refractory life in this increasingly important type of melting.***

ing point, the more refractory products, such as high alumina and sillimanite, should be investigated.

The following refractories are basic:

Magnesite

Fused Magnesia Forsterite

Improved Magnesite Refractories

Magnesite is becoming more widely used, almost daily, in the side walls of basic direct-arc furnaces. It resists the attack of basic slags very well. It is available in improved and modified forms that are rapidly displacing the old standard magnesite brick. Slags containing excess silica will attack it quite rapidly at temperatures above 2800° F. Likewise, drip from silica roofs, running down the side walls, channels into the magnesite with alarming rapidity at times.

This is overcome by some operators through the use of a "buffer" course of chrome brick between the two. Chrome will not react appreciably with either material. Magnesite's poor spalling resistance and low hot-load capacity have limited its application somewhat. These shortcomings have been minimized in recent years, but there is still room for improvement.

Forsterite brick are relatively new and have yet to find appreciable application in electric furnace operations. Basic slags apparently attack it at a somewhat greater rate than in the case of magnesite.

Fused magnesia is used principally as a lining material for high frequency induction furnaces, most frequently with an addition of approximately 30 per cent of fused alumina. Fused magnesia has found no other applications in ferrous melting. It is not to be confused with sintered magnesite, so widely used as a basic bottom material in three-phase arc furnaces.

Neutral Refractories

Chrome and fused alumina are classed as neutral refractories. Chrome comes nearest to being neutral, chemically, of all the more common refractory materials. It has very excellent resistance to both acid and basic slags and fluxes.

It is frequently used as a "buffer" course between acid and basic refractories. Perhaps the largest percentage of chrome today is used in brick combined with magnesite to make the so-called chrome-magnesite refractories that are being more widely used day by day.

The application of the higher-chrome-content refractories has been limited in electric melting by the fact that chromium metal is fairly readily reduced from the refractory during the periods in which reducing conditions prevail in such operations. Many times this feature is given undue stress, but there are conditions where it must be considered.

Fused alumina also is rated as a neutral refractory, but it does not have the resistance to basic and acid slags or conditions to the degree that is often implied. The use of straight fused alumina products cannot be generally justified outside of laboratory operations.

As pointed out, fused alumina has found its principal application, when mixed with fused magnesia at a ratio of about 30:70, as a lining material for high frequency induction melting units. In this instance it has been very satisfactory, but as tile and brick for linings in direct- and indirect-arc units, alumina products have not shown advantages commensurate with the high cost.

Composition Equilibrium

Essentially, within practical limits, a refractory with a composition most nearly in equilibrium with the slags and fluxes present in the melting operation should be chosen. Thus in a basic operation the use of magnesite products will generally give the most satisfactory results, as will silica in acid melting operations.

Other factors to be discussed limit the degree to which this may be carried out. A compromise is always necessary in the selection of a refractory for a high temperature melting operation.

The fluidity of the slag or reaction product has a great influence on the degree of destruction of refractories by chemical attack. If the slag is quite fluid and flows over the face of the refractory with relative rapidity, the corrosion rate also is rapid. The products of the corrosion are carried away, leaving a new surface of refractory open for attack.

As the viscosity of the slag or reaction product increases, the rate of the attack is reduced proportionately. A point may be reached where, actually, the reaction product is of such viscosity and refractory nature that it will effectively serve as a protective layer against further attack. This condition is seldom if ever reached in electric melting operations.

Operating Temperatures

The temperature at which melting operations are carried out will likewise affect the chemical attack. In some instances, chemical activity increases most markedly with temperature rises. This, coupled with increased fluidity of reaction products, means greatly accelerated erosion rates.

Temperature limits can be, and often are, very critical. Not infrequently, by carrying the temperature even 20 or 30 degrees lower, a marked improvement in refractory service is obtained. It is certain that silica roofs and side walls are not going to stand up at temperatures of 3100° F. as well as they will at 3050° F.

In the case of basic brick, temperatures that will actually fuse the brick are not likely to be reached. Temperatures can be and are reached that will soften the bond betwen the refractory grains of the brick. Thus, the brick loses most of its strength.

Molten metal and slag, if active, may wash the bonding material from around the refractory grains, which are in turn carried away. Because of the lack of hot strength, basic brick have not yet been successful in direct-arc furnace roof construction.

The temperature difference between the hot face and the cold face of the refractory is important. It is because of this difference that brick can be used at temperatures equal to their fusion point.

Temperature and Load

That portion of the brick away from the heat source carries the structural load—if the brick were at the hot face temperature throughout, failure would be rapid. Insulation of direct-arc furnaces will lessen the life of the refractories, as the outer surface of the brick tends to approach the extreme temperatures of the hot face.

Likewise, the steeper the temperature gradient, that is, the greater the difference between the hot- and cold-face temperatures, the less the

penetration of fluxes and slags into the brick proper. This latter, of course, means a slowing down of chemical attack and, too, a lesser depth of vitrification of the refractory. This is important in the consideration of spalling.

The porosity of the refractory also affects the rate of chemical attack. If the brick is open in structure, the metallic vapors and fluxes can penetrate into the brick structure more readily and thus attack a greater portion of the brick at one time. As has been mentioned, the composition of the refractory relative to that of the slagging or fluxing agents present will markedly affect the reaction rates.

As previously stated, FeO will not attack silica refractories at an appreciable rate alone until a concentration of 40 per cent FeO is reached, but the addition of a small amount of alumina will cause the reaction to proceed rapidly and with but a small percentage of FeO present. Similarly, an FeO-CaO slag will not attack magnesite brick appreciably, but if SiO_2 is substituted for the CaO the attack will be rapid.

Refractory Erosion

Erosion of refractories is the wearing away of the refractory by slags, molten metal and flame or flux burdened hot air currents over their surfaces at varying rates. Invariably this is a combination of mechanical and chemical wear. Generally speaking, the more rapid the rate of flow, the greater the amount of erosion for a given period of time.

In furnaces such as the high frequency induction and indirect-arc rocking-electric, erosion is inherent to their operation; in the direct-arc unit it is incidental, varying with bath activity. In no case can it be completely avoided.

Spalling. Spalling is the separation of a brick or refractory mass into two or more pieces, resulting from stresses incurred under service conditions. Spalling is of three types; thermal, structural, and mechanical.

Thermal spalling is the result of rapid and unequal expansion or contraction of a refractory mass due to non-uniform heating or cooling of the mass. This can never be completely eliminated in production operations. With care in the selection of the refractories, and in the operation, it can be minimized.

Heating and Cooling Rates

Most important is the selection of heating and cooling rates best suited for the refractories involved, and making certain that the furnace is protected from air currents circulating through it as the unit is cooled.

Thermal spalling may be recognized by the typical "cobblestone" appearance of the surface of the masonry. Silica, magnesite, and chrome refractories are most subject to thermal spalling; sillimanite types and super-duty fireclay refractories the least. Generally speaking, a refractory of open "elastic" structure will be the most spall resistant.

The more dense and finer-grained brick are most likely to be susceptible to spalling. Other things being equal, the brick having the greater expansion coefficient will spall the most. Silica is unique in that it undergoes two abrupt volume changes in being heated to a temperature of 1100° F. Above that temperature it is practically volume stable and can undergo marked temperature changes without damage.

Extreme caution should be observed when heating or cooling it between 300 and 500° F., and again from 900 to 1125° F., as all thermal spalling of silica will occur within these temperature ranges.

Structural Changes

Structural spalling results from a change in the physical structure or mineral composition of a refractory due to the action of heat or the combined action of heat, slags and fluxes. Often this change results in a material more subject to thermal spalling or shock than the original structure.

Thus, when a brick end has become vitrified or glass-like, the resulting brittle mass can stand very little temperature variation without undue stresses developing within the mass, which stresses are relieved only through cracks forming in the brick.

Similarly, when heat has caused the bond between the refractory grains to soften, the entire mass shrinks into a more dense form of less porosity and volume. In this, and the first condition, the altered part of the brick tends to pull away from the original structure at the transition zone between the two portions. Relatively slight thermal or mechanical shock that otherwise would have no effect may result in a separation near the transition zone.

New mineral forms, resulting from the action of heat and from chemical attack, may be of greater or less specific volume, resulting in a condition similar to shrinkage. The expansion characteristic also may be altered in the new mineral form. Any of these will mean a greater tendency toward spalling. Such spalling is called "structural," although thermal shock may play an important part in ultimate failure.

Alumino-silica refractories such as super-duty, fire clay, and sillimanite or mullite types, along with magnesite and chrome, are more likely to suffer structural changes resulting in structural spalling than is silica.

Masonry Structure

Mechanical spalling is the result of concentrated stresses developed in the masonry structure, generally due to faulty masonry. When these stresses are sufficiently great the brick fractures to relieve these strains. This type of spalling is most generally found in arches that have been laid up too tightly.

When they are heated the expansion of the brick causes the crown to push upward and the stresses are concentrated in the lower edge of the brick, on the under side of the arch, rather than being distributed over the entire brick surface. "Pinching" results, the lower ends of some of the brick breaking away until the stress distribution is more uniform.

Insufficient Refractoriness. This is not unusual in electric melting operations. Fireclay refractories almost invariably fail in electric melting operations because they begin to soften long before actual melting begins. Most high quality fireclay refractories have a fusion point at temperatures of about 3100° F., but they soften well below this temperature and it is doubtful if they are of

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much use in electric furnaces at temperatures of about 2950° F.

Silica has a fusion point just below 3100° F., but fortunately it does not soften until just a few degrees below its fusion point. Its usefulness in electric melting is markedly greater than that of fireclay products in spite of the fact that the latter have a considerably higher fusion point in some instances. Sillimanite has a fusion point approximately 3335° F. and, like silica, does not soften until within a few degrees of the fusion temperature.

Fusion Temperatures

Both chrome and magnesite refractories have fusion temperatures above those used today in electric furnaces. Unfortunately, the bond material in these brick will soften at much lower temperatures, so the brick fail if stressed or loaded to any appreciable degree. Zircon, which is finding application in electric melting, also has an extremely high fusion point.

Much has yet to be learned of the limitations of zircon in electric furnaces. It does seem to have merit when used in indirect-arc rocking electric furnaces melting ferrous alloys. High alumina fireclay brick have sufficient refractoriness but are subject to excessive shrinkage when exposed to high temperature for long periods, such as in electric furnaces. They too soften at temperatures appreciably below their ultimate fusion temperatures.

Mechanical Abuse. Mechanical abuse is something about which the refractories manufacturer can do nothing. It is strictly a plant operator's problem; a difficult one today with the class of labor now available. Most mechanical abuse takes the form of direct destruction of refractories by lack of care in charging and rabbling.

Such abuse generally contributes more than is realized to the ultimate failure of refractories, particularly those about the doors and at the metal line. Guarding against such abuse deserves more time and consideration than is usually given it.

Insufficient hot strength is found principally in fireclay refractories and in chrome and magnesite products. In the former, the entire mass of the brick softens and will not support a load. A roof of fireclay will sag while it is otherwise still serviceable, particularly if the operation is a cold melting one.

This sagging is due to the loss of hot strength as the brick progressively softens at temperatures well below its ultimate fusion point. If it were not for this, fireclay refractories would undoubtedly be used for roof construction in many more operations than it is at present. With chrome and magnesite refractories, the basic refractory grains do not soften but the matrix or bond surrounding these grains does.

As liquid develops in this matrix it acts as a lubricant to the grains so that they may slide over one another; when sufficient liquid develops the brick will no longer stand any loading. Grain shape and characteristic determine the amount of liquid necessary before failure occurs. If the grains are rough, more liquid is required than when they are rounded and smooth. If they had interlocked surfaces they probably would be able to stand up until chemical attack alters the surface.

Unfortunately, grain intergrowth does not occur in magnesite refractories, and increasing the hot strength of these refractories is a difficult problem. Progress is being made, but it appears that it will be some time before a basic roof for electric furnaces will be possible if made in the conventional sprung-dome form.

Silica, sillimanite types and superduty fireclay refractories have the greatest hot strength under load; magnesite and chrome the least.

Direct-Arc Furnace

Roof Construction. Since by far the largest percentage of electrically melted ferrous metal is produced in this type of unit, it is logical that refractories for the direct-arc furnace should be considered first.

The principal causes of failure of the refractories in a direct-arc furnace roof are chemical attack from the furnace atmosphere, spalling, and temperature. These causes are not necessarily listed in the order of importance, as the more serious of these various factors of destruction will vary from plant to plant. In all cases, however, each will contribute significantly to the ultimate failure of the refractory.

It might be well to stress that, while the main body of the roof construction is subject to attack as previously indicated, the conditions causing failure are more intensified at the center portion of the roof, and more specifically around the electrode openings.

The chimney effect created by these openings results in the constant washing of the refractory around the opening by the flux-laden atmosphere of the furnace. The chemical attack on the refractory at this point of the roof construction is thus greatly accelerated. In addition, thermal spalling is more serious in this part of the construction.

Realizing this fact, it is not difficult to comprehend why roofs are so often removed from service due to failure of the delta-section while there is still a serviceable thickness of refractory remaining in the balance of the roof. Investigation of a super-refractory, such as sillimanite, to reinforce this portion of the construction might be advantageous.

Silica in Roof Construction

Silica is by far the most commonly used refractory material for roof construction in this type of melting unit. The relatively high hot strength of silica makes it particularly adapted to this application.

While it is conceded that neither the fusion point nor the resistance to chemical attack by the fluxes present is the ultimate for an electric furnace roof refractory, it must be agreed that silica is sufficiently resistant to these forces of destruction to make its application practical.

A serious objection to the use of silica roof construction is its characteristic irregular expansion, which makes the material susceptible to thermal spalling. This characteristic is particularly objectionable where the furnace operation is intermittent.

A satisfactory solution to this difficulty is the use of a gas burner in the furnace to keep the temperature above the critical expansion range of silica. The tendency of silica to spall might also be a factor in top-

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

charge furnaces, but under normal operation the roof is not off the furnace long enough to cool the brick below the critical temperature.

In either of these instances, the use of an improved silica cement now available will help reduce excessive wear of silica brick or shapes due to thermal shock. While the cement will not prevent the silica from cracking, it will be of positive aid in preventing the cracked portion of the brick from falling away to leave new surfaces exposed to further attack.

Another serious objection to silica roof construction is contamination of the slag from silica drip. Under certain operating conditions, this siliceous drip can be sufficiently serious to make a silica roof impractical. This factor is of consequence only in basic operation.

As indicated, despite the common application of silica for roof construction, it does have its shortcomings. Consequently, we find other refractory materials used in place of silica. Due to their increased thermal spalling resistance, super-duty fire brick are sometimes used successfully in place of silica, but the extent of the application is limited because of the characteristic softening of such brick under load at temperatures appreciably below their fusion point.

Alumina-diaspore, or high alumina, kaolin, and sillimanite are used to a limited extent. Despite the relatively high initial cost of these materials over fireclay and silica, their application proves economical under certain operating conditions. The good hot-load bearing and high refractory characteristics of these materials make them adaptable to the application under discussion.

Roof Refractory Properties

The excessive shrinkage of the diaspore-alumina material is objectionable, and undoubtedly is a limiting factor in its use for roof construction. All of the foregoing materials, being Al_2O_3-SiO_2 refractories, are adversely affected by the iron oxide dusting from the furnace atmosphere.

The diaspore-alumina and sillimanite refractories are also subject to structural spalling resulting from the absorption of fluxes at the hot face.

The reaction of the refractory with these fluxes, at the high operating temperatures, forms a product with a different specific volume than the original brick. When the furnace cools, this reaction product peels away from the main body of the refractory, leaving new surfaces exposed to attack. Depending upon conditions, the effect of this reaction will be to a depth of ½ to 1 in.

Despite these limiting factors, sillimanite, due to its high refractoriness, excellent hot strength and resistance to thermal spalling, is particularly adapted for electric furnace roof construction. The high cost of sillimanite is the principal consideration limiting its more general acceptance for this application.

Chrome-Magnesite Refractories

Although chemically suited and amply refractory for direct-arc furnace operation, chrome-magnesite brick have not been used in electric furnace roof construction with any success. The lack of application can be attributed to the structural weakness of the present basic brick, which will not withstand the stresses and strains of the present dome-shape construction.

In this application, structural spalling, due to iron oxide absorption at the hot face, would also be encountered. This type of brick is also susceptible to thermal spalling. These latter two factors, however, would not prove too serious if the manufacturers of basic brick are able to improve significantly the structural weakness of the present day product.

Investigations are now under way to develop basic roof brick for the basic open-hearth furnace. Developments from this work may prove adaptable in foundries following the basic practice.

Bottom. Although subject to significant slagging action, it is probably the abrasion from charging that is the most serious factor affecting the furnace bottom. The maintenance of a tight monolithic structure also is important, as development of cracks will permit penetration of molten metal, resulting in eventual disruption of the hearth.

In acid practice, the hearth will be a monolithic construction of either sand or ganister. In basic practice, the hearth will be a sintered magnesite, or more likely, a rammed magnesite. This latter, a relatively new development, seems to have become definitely established practice.

Side Walls. The side wall refractory must withstand chemical attack, as well as the erosive action of molten metal. The metal line of the side wall is particularly vulnerable to the destructive action of fluxes, slag, and molten metal. Where reasonable care is not exercised, mechanical abuse can be a significant factor in side wall failure.

In acid practice, the side wall will be silica brick. At least one operator is using a sillimanite plastic for the side wall construction but, due to the initial cost of this material, few such applications could be justified.

In basic practice, complete side wall construction of magnesite brick is generally used. Rather than use this more expensive class of brick up to the roof skew, some operators prefer to limit the application to several courses above the slag line, finishing the construction with silica brick.

A course of neutral chrome brick is recommended between the acid silica and the basic magnesite. The elimination of this course of brick, however, has not proved to be of any serious consequence in actual practice.

Door Arches and Jambs. Since this portion of the refractory construction is, in effect, part of the side wall, it is subject to the same factors affecting the life of the side wall above the metal line. In addition, door arch and jambs must also withstand thermal spalling.

General Refractory Uses

In general, the refractory used for the side wall construction will also be used for the door arch and jambs. In furnaces of 1000-lb. rated capacity or larger, super-duty brick or sillimanite are sometimes used to take advantage of the spall-resistant characteristics of these materials.

On units of under 1000-lb. rated capacity, it is not particularly practical to construct the door arch and jambs of a material different from that used in the side wall. Where door arch and jamb maintenance is a particularly serious problem, the use of water cooling in place of the refractory should solve the problem. However, this type of construction in the foundry-size units has not found application to date.

General. Before leaving the subject of the direct-arc furnace, it

might be pertinent to call attention to the unnecessary damage that is done to side wall and roof refractories from the use of high-tap voltage at the start of the melt down.

It is debatable that any time benefit is actually gained by starting the furnace on high tap but, even conceding that very questionable point, it is safe to say that any saving in time is made at a cost out of proportion to the resulting damage to the exposed refractories. The use of intermediate tap until the electrodes are buried in the charge will pay worthwhile dividends in prolonged refractory life.

High Frequency Induction Furnace

By comparison with direct-arc furnace melting, the tonnage of foundry steel melted in this type of unit is small. Also, by comparison with the direct-arc furnace, the high frequency induction furnace is a small consumer of refractories. However, the refractory problems encountered are of no less consequence.

The refractory material used to form the crucible must have good hot strength, not only to meet the service conditions imposed, but also because the refractory crucible thickness must be kept at a minimum in order to realize the highest possible electrical efficiency.

The refractory crucible must also withstand the fluxing action at the metal line, as well as erosion throughout the crucible depth. These conditions are aggravated by the continual self-stirring action of this type of melting unit.

In commercial size units, the crucible will be either a rammed ganister or a rammed mixture of fused alumina and magnesite. The material used will, of course, depend upon whether the process is acid or basic practice.

Rammed Linings

In acid operation, it has been reported that a rammed sillimanite lining is outlasting silica three to one. This application of sillimanite is very limited, but perhaps a more extended investigation might be worthwhile in acid practice.

The use of preburned crucibles is limited to the laboratory size units due to the difficulties of manufacturing and handling such a crucible. Where a preburned crucible is used, the space between the crucible and the coil is packed with magnesia, fused alumina, or silica sand. Zircon sand also is reported to have been successfully used for such application*.

While the crucible construction represents the major refractory application, there are two other applications which warrant attention. One of these is the use of a plastic material for coating the inside surface of the copper coil prior to the installation of the crucible.

This material should have good air-setting properties and a high specific resistivity factor. It also is important that the material withstand any tendency to crack. The thickness of this lining will be approximately ¼-in. This refractory serves as a protection to the copper coil in the event of crucible failure during operation, and also serves to give rigidity to the copper coil.

The second minor refractory consideration is the use of a refractory to form the lining above the slag line, including the spout. This portion of the furnace is subject to serious mechanical abuse, as well as to metal erosion when the furnace is tapped.

Mechanical Strength

Since the refractory used for the construction of this part of the furnace is not subject to sufficient temperature for any period of time to develop a good ceramic bond, it must have good cold-setting properties to provide the necessary mechanical strength. The material used must also be sufficiently refractory to withstand the temperature of the molten metal while the furnace is discharged. A sillimanite plastic will very satisfactorily answer all the requirements of the refractory in this application.

Homemade mixtures of either basic or siliceous materials with sodium silicate or high temperature fireclay cement can also be used. While this latter practice is an inexpensive solution, it is questionable that the service is comparable to that obtained from the sillimanite material.

Ferrous foundry operators have found this melting unit to fill a definite need in certain classes of work. Its use in ferrous melting operations has grown markedly during the past 12 or 15 years.

As melting operations for iron and steel are carried on at greater temperatures than are normally used in non-ferrous work, the refractory manufacturer has been faced with a real problem to develop an all-around good refractory.

Refractories for these melting units must be able to withstand chemical attack, erosion, thermal and structural spalling and, to some degree, mechanical abuse. Likewise, they must have a high fusion point.

While all portions of the lining are subjected to extreme temperatures, those parts that are washed by the metal as the furnace rocks do not suffer particularly from excessive heat. However, this advantage is overcome by the erosion resulting from the washing action of the metal bath.

Thermal Shock

The whole furnace lining is subjected to thermal shock during shutdown periods. This can be minimized if care is taken to keep the furnace closed as tightly as possible after the power is cut off. Thermal shock is always a hazard around the door, even during operating periods.

Chemical attack, while not pronounced if care is taken to charge relatively clean scrap, is always present to a degree. Most operations are carried on without slagging. Thus the only slag produced is that formed by reactions between foreign material in the charge and the refractory.

This slag is quite viscous and, except for the rocking action, might otherwise serve as a protective coating on the lining. In normal operating procedures the furnace atmosphere is relatively clean and contributes very little toward lining destruction.

Where the furnace is used in duplexing operations, high power inputs are not necessary. Under such conditions lining life is much improved over cold melting practice.

Selecting Refractories

As in all electric melting operation, it is difficult to conceive of a fully satisfactory refractory for this service. Basic brick will not do for reason of their high thermal expan-

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*G. F. Comstock, "Lining a Small Induction Furnace," *Metal Progress*, Dec., 1939.

Melting MAGNESIUM *Alloys*

By L. M. Nash, Production Manager and Metallurgist,
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DUE to the greatly increased demand for magnesium alloy castings for war purposes, and to the necessity for training new personnel quickly, there was a general pooling of knowledge by the magnesium industry. The result of this is that all phases of the handling of magnesium have been well covered by many of the trade publications and also by government sponsored research. However, a general review of the "melting process" step by step with emphasis on the important points may prove helpful.

At the present time there are three principal methods of melting magnesium:

1. The wet flux method for refining and casting.
2. The crucible method used in sand and large permanent molds.
3. The sulphur atmosphere method used only for low temperature work, such as die castings.

Wet Flux Method

The wet flux method is now used mostly for alloying and refining and as a holding furnace for crucible melting. This process consists of using a flux, composed chiefly of magnesium and sodium chlorides, which is very fluid and melts at temperatures several hundred degrees below the melting point of magnesium alloys.

The melt consists of about one-third flux, most of which stays at the bottom of the pot, with just a thin film of flux over the top of the metal and down the sides of the pot. Pouring is done from this pot by means of a bottom-pour hand ladle. The flux is swept from the top of the metal with a lip on the side of the ladle, and once a ladleful is removed the flux again covers the metal surface, keeping it completely protected from the atmosphere.

Because of the large amount of flux used and the design of the pot, which is roughly a half sphere, this is the best method yet developed for cleaning and refining magnesium.

• General pooling of knowledge and extensive research made possible the wartime production of magnesium alloy castings. Developments in magnesium foundry melting presented before Southern California Chapter of A.F.A., Oct. 12, 1945.

The flux can be stirred thoroughly through the metal and thus perform a very efficient job of removing dirt and oxides.

The presence of oil and paint will destroy the flux efficiency rather quickly, so that often it is more economical to remove excessive amounts of these impurities before melting. However, very dirty and badly oxidized scrap can be put into first class condition by this process. It was developed in this country by the Dow Chemical Co. and was the principal process used in magnesium melting until about 1937.

The greatest drawback to this method is that, unless extreme care is exercised by an experienced operator, it is very easy to dip flux out of the pot with the metal and leave traces of flux in the castings poured. As the flux has a great affinity for moisture, it will show up in the castings as grayish-white spots in a few days, or even overnight in a humid atmosphere.

These spots continue to grow in size as corrosion progresses, and usually cannot be removed but continue to re-appear no matter how often the casting is re-sandblasted and pickled, thus making the casting unfit for use. This method is being used successfully in production foundries where the molds can be conveyed to the furnaces, but is difficult to use in a jobbing shop as there is no way to transport or pour more metal than can be carried in a hand ladle.

Crucible Method

Because almost any amount of metal can be prepared and poured from the crucible, this method has become that most commonly used by the foundry today. This process was first developed in Germany but, due to patent and development difficulties, did not get much of a start in this country until 1935.

The crucible melting method consists of a batch process somewhat similar to that used with brass, where the metal is melted in and poured from the same crucible. With magnesium alloys the metal is melted with a small amount of flux in a welded steel crucible.

Because there is a very slight iron pick-up, which lowers the corrosion resistance, steel crucibles are not the perfect melting medium, but all other types are bonded with clays containing silicon, which will alloy with magnesium. The only exception is the silicon-carbide crucible, and present work being done indicates this crucible as a possibility.

Preventing Oxidation

The foundry practice used for magnesium alloys is, in general, the same as that used for any other metal. The main difference in the practice is the necessity for preventing oxidation. The word oxidation is used here as a general term because magnesium not only combines readily with the oxygen in the air, but almost as readily with the nitrogen.

It is this chemical activity that has to be guarded against if good castings are to be produced. Inhibiting agents must be added to the core and molding sands, fluxes must be used in melting and an inhibitor must be dusted on the metal stream during pouring. Overlooking this basic fact causes most of the trouble met with in magnesium foundries.

If the practice is to melt the metal directly in the crucible, the first point to be watched is the condition of the scrap. One of the main advantages of the crucible method is the minimum amount of flux used.

All scrap should be sandblasted

to remove as much of the surface oxide and dirt as possible, and scrap that cannot be properly cleaned should be separated and melted only by the wet flux method and poured into ingots for future use, or be discarded altogether. A crucible melt using 100 per cent scrap can be just as good or better than one made with virgin ingot provided that sufficient care be taken to see that the scrap is clean.

Silicon Content

All traces of sand must be removed from the scrap, regardless of the melting method used. Magnesium combines quite readily with silicon, and a relatively small amount of silicon produces brittleness and also interferes with proper heat treatment. All specifications for magnesium alloys allow a maximum of 0.3 per cent of silicon, and this is two or three times the amount that will be present if the scrap has been kept clean. Silicon can be held to about 0.05 to 0.06 per cent.

During the melting operation, care must be taken to keep the metal covered with flux as it melts down. Any oxides produced in melting increase the amount of time and labor needed to clean the metal. If melting is carelessly done, it may be impossible to really clean the metal.

One form of crucible melting practice consists of a double fluxing operation, where a relatively wet flux is used to first clean the metal and a dryer flux then used for protection. This can be a very good procedure to clean dirty metal, but again it increases the danger of flux inclusions if too much wet flux is used. In the author's opinion, it is safer and easier to take a little more care before and during the melting to make this step unnecessary.

Stirring the Melt

The next step in melting is the stirring operation. The temperature at which this is done is not very critical, but it seems to work best at temperatures of 1350° to 1425° F.

These temperatures are about as high as can be used if excessive oxidation is to be prevented during stirring. Inasmuch as the purpose of stirring is to remove oxide, it would be poor practice to perform the operation at a temperature which would produce more oxide.

The stirring is done with an iron rod, preferably square, and long enough to reach the bottom of the pot. The operation consists of stirring the metal rather vigorously with a circular motion so as to make the metal in the pot actually rotate. This is accompanied by an occasional sprinkling of flux to keep a flux cover on the surface of the metal to trap the oxides.

This operation takes from 1 to 5 min., depending upon how carefully the operation has been conducted up to this point. When properly done, the metal will present a silvery, bright, mirrorlike surface when skimmed. If improperly done, the surface will have the appearance of being pimply, due to the presence of small oxide particles floating near the surface. If the metal is poured in this condition it will be of poor quality and, as the oxide particles left in the melt are partially coated with flux, they will produce flux spots on the castings.

The mechanics of the stirring operation seem to be twofold:

1. Flux is stirred into the melt where it can come into contact with the dirt and oxide particles, and after these particles become coated with flux they no longer hang in suspension in the melt but sink to the bottom or float to the top, depending upon their specific gravity.
2. Centrifical force set up by the rotary motion probably forces some of the heavier particles to the crucible wall, where they cling to the flux left on the wall during melting, and the lighter particles move toward the center where they are trapped in the flux added in stirring and then rise to the surface when stirring stops.

After stirring has been completed, the material accumulated on the surface is removed with a skimmer and a new light dusting of flux is added. As this entire operation should not take over 3 or 4 min., it usually is unnecessary to interrupt the heating of the melt.

Superheating the Melt

The next step is to heat the melt to a temperature of at least 1600° F. for not less than 20 min., or as high as 1700° F. for approximately 10 min. This superheating procedure produces a finer grain size in the melt and, as grain size and strength are related, it is important to produce as fine a grain as is possible.

After superheating the metal should be held at a temperature of not less than 1450° F. until it is ready to pour, and then cooled as quickly as possible to pouring temperature. This is because the effect of superheating is lost quite rapidly if the metal is held for a period of time at a lower temperature. The next point to watch in order to help prevent having flux inclusions in the castings is that no flux should be added to the melt for at least 10 min. before pouring.

The flux when first added is only slight wet, and in this state it can easily flow with the metal into the mold. After heating for a few minutes, the flux becomes thick and sticky and will cling to the crucible. On the surface of the metal when it is exposed to the air it forms a hard crust. This hard crust will protect the metal perfectly, and can be removed or pushed out of the way just before pouring.

Only the dusting agent should be used to prevent burning from then until pouring is completed. Also, all accumulations of flux on the pouring lip and rim and ears of the crucible should be brushed off. The total amount of flux necessary to complete the melting operation should not be more than 2 or 3 per cent by weight of the metal melted.

Gas Causes Porosity

Normally, magnesium dissolves very little gas, and it is only recently that it was found that hydrogen does dissolve in it. During the past 3 years much work has been done on this subject, and it has been proven that the presence of gas has a very pronounced effect on the amount of porosity present in magnesium alloy sand castings, especially in heavy sections.

Much of this gas comes from moisture. Because of this fact it is essential that all materials should be as dry as possible. The scrap, ingot, and tools should be preheated on the top of the furnace even when they seem to be dry, because the amount of moisture necessary to cause gas would not be as much as is needed to blow metal out of the crucible.

The most difficult material to keep dry is the flux. As it is composed largely of chlorides, it can contain enough moisture to cause considerable gas trouble without appearing

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Combustion Method for

SULPHUR DETERMINATION

in White Cast Iron

James Hedberg, Research Chemist, and H. A. Schwartz, Manager of Research,
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• Malleable iron foundries . . . combustion method for sulphur determination adapted to works control . . . accurate results obtained in 12 minutes.

RESULTS of sulphur determinations made by the standard rapid method most commonly used today have long been recognized as unreliable. However, the evolution-titration method has continued in vogue because it is rapid and requires no special equipment. Low and non-reproducible results often encountered with alloy and white irons can be obviated to some extent by annealing the sample, but this more than doubles the time for a determination and does nothing to minimize errors inherent in the analytical procedure.

Combustion methods, which have become increasingly popular because of speed and accuracy, were examined with the idea of developing a procedure suitable for works control in malleable iron plants. An accurate result, obtained by the method described, is available in a total time of 12 min.

Methods Investigated

In the program for determining sulphur, in white cast iron, by combustion, several methods were investigated. Two iodate methods having been discarded, a method suggested by G. M. Guiler of this laboratory was tried. Based upon information obtained in an abstract* in *The Engineers Digest,* p. 187, Feb., 1944, the procedure involved the use of a silver nitrate solution as an absorbent.

In this method the sulphur dioxide gas formed, when the sample is ignited at a high temperature in an oxygen atmosphere, is absorbed in a neutral silver nitrate solution. With water, sulphur dioxide forms sulphurous acid which reacts with silver nitrate to form an equivalent amount of nitric acid. This is illustrated by the following equation:

$$H_2SO_4 + 2AgNO_3 \rightarrow Ag_2SO_3 + 2HNO_3$$

Titrating the liberated nitric acid with a standard sodium hydroxide solution gives an index of the sulphur content of the sample.

Equipment Required

The apparatus required is very simple but the method may perhaps be adapted to more elaborate equipment on the market. An ordinary cylindrical combustion tube in a furnace capable of maintaining a temperature of 2350° F. may be used. Because the temperature must be maintained accurately, a platinum thermocouple, touching or near the outer surface of the combustion tube, and a deflection type indicator, are suggested.

Glass tubes passing through rubber stoppers, which are protected by nickel shields, serve as inlet and outlet to the combustion tube. A tube with a constricted end might be preferable.

The horizontal passage from the combustion tube, containing a stopcock, is bent vertically downward to enter the absorbing vessel, a 75-ml. tall bottle. Immersed to a depth of about 4 cm. in the absorbing solution, the end of the vertical tube is fashioned to break the gas stream into fine bubbles. It has been found that most accurate results are obtained when the passage from combustion tube to the bubbler is of the shortest length.

Oxygen for combustion is purified by bubbling through concentrated sulphuric acid. Rate of flow must be capable of accurate control and measurement in the range of one liter per min.

Reagents Used

Standard Sodium Hydroxide Solution: To 20 ml. of water add 0.500 grams of C.P. sodium hydroxide and 0.03 grams of methyl red. Dissolve, and make up to one liter. This solution should be standardized against a standard acid which has been prepared and standardized in accordance with well-known methods.

Silver Nitrate Solution: Dissolve 2.0 grams silver nitrate in water and make up to one liter.

Procedure: Weigh a 0.500-gram sample of white cast iron, finely crushed, and place in a refractory boat. Cover with a shield and place in the hottest part of the combustion tube, which should be between 2300° F. and 2400° F. Close the tube and, after allowing a one-min. warm-up period, turn on the oxygen at a rate of one liter per min., at the same time opening the stopcock to the absorbing vessel.

Five min. after the oxygen is turned on, slow the stream of oxygen somewhat, and titrate to neutrality with the standard sodium hydroxide solution.

If the standard solution contains 0.500 grams of sodium hydroxide per liter, the number of milliliters of this solution multiplied by 0.04 gives the percentage of sulphur in the sample.

Accuracy within plus or minus 0.0018 per cent sulphur may be ex-

*Originally from a paper of The Iron and Steel Institute, London, November, 1943, by the Blast Furnace Analysis Sub-Committee of the Blast-Furnace Committee.

Sponsored by the Committee on Chemical Analysis of A.F.A.

pected. If the oxygen is passed through the tube for 10 min. instead of 5 min., the results are sometimes 0.002 per cent higher.

Routine Precautions

When a new combustion tube or new bubbler is introduced into the apparatus, a check should be made, by running a standard cast iron sample. If correct results are not obtained on the first sample, the second sample usually gives the correct result and indicates that the apparatus is ready for the determination in hand.

A very common and important cause of erratic results is increasing the rate of oxygen flow appreciably beyond the one liter per min. This will give low results due to alkalies from the combustion of the cast iron being blown over into the absorbing solution and reacting with the HNO_3 in the solution.

Low results will also be obtained if the apparatus is blown out with oxygen previous to a determination at a rate appreciably higher than one liter per min., possibly due to alkalies from the combustion tube from previous determinations being blown over and accumulating in the lower part of the bubbler.

Effect of an oxygen flow slower than one liter per min. has not been investigated thoroughly, although it has been noted that low results are obtained if the flow is cut roughly in half.

Any dampness in the part of the bubbler or its connections above the part which enters the absorbing solution naturally will cause low results due to absorption of SO_2 before it gets to the absorbing solution.

New boats should be ignited under operating conditions before they are used; used boats should be treated similarly if they have been allowed to stand more than 8 hr. Although they can be used four or five times, it is better not to use a boat more than three times.

Combustion tubes have been used for about 300 determinations, without cleaning and without noting any change in results.

Typical Results

A test run using the silver nitrate method on a standard sample of white iron is shown in Table 1. Tabulated are the results of successive determinations made during a period of 7 hr. total time. Thus 34 successful determinations, plus one which was discarded, were made at an average rate of one analysis every 12 min.

Table 1

DETERMINATION OF SULPHUR IN WHITE IRON

Sulphur, per cent			
0.142	0.146	0.140	0.138
0.146	0.144	0.142	0.143
0.144	0.142	0.141	0.141
0.144	0.144	0.141	0.144
0.142	0.142	0.140	0.143
0.141	0.143	0.142	0.144
0.143	**	0.142	0.141
0.140	0.140	0.141	0.140
0.143	0.140	0.140	
*	*	*	

Average of 34 determinations, 0.1420 per cent sulphur.

Standard deviation, 0.0018 per cent sulphur.

*Ignited Boats.
**Determination discarded due to bad bubbler.

Advantages. The titration end point of this method is easy to see, and is not affected by carbonates. Although averaging slightly under those obtained by gravimetric methods, the results are based on theoretical chemical equations, and require no empirical correction factors or standardization against standard samples. The method gives correct results on National Bureau of Standards samples and the accuracy of the method described is confirmed by using the barium sulphate method.

Requiring no attention until titration, after the oxygen is turned on, time is saved by weighing the sample for the next determination. The results of titration of the absorbing solution depend upon the acidity of the solution rather than the oxidation of sulphurous acid to sulphuric acid, thereby eliminating any error due to sulphur trioxide coming over with the sulphur dioxide.

Twin City Citizens View Castings Exhibit

THE motor of an OQ radio controlled target plane, pictured in *Life,* October 15, has been on display recently at the James J. Hill Reference Library, St. Paul, Minn. Part of an exhibit of castings furnished by Twin City chapter members, it has attracted much attention. The castings, supplied by 18 foundries of St. Paul, Minneapolis, Lake City and Fairmont, illustrate the widespread use of foundry products. Cast iron, malleable iron, steel, bronze, brass, aluminum and magnesium are all represented in the castings which include a three stage air compressor, B-29 bomber parts, faucets and valves, railroad castings, ornamental castings, pistons, cylinder blocks and heads, washing machine motor parts, parts for farm implements, etc.

The Librarian reports that a number of student groups have already viewed the exhibit in response to the invitation sent to all high schools, industrial schools and the university.

(Photo courtesy M. E. Seaquist, Paul Pufahl & Son, Minneapolis)

Castings exhibit sponsored by the Twin City chapter which has been on display at the James J. Hill Reference Library, St. Paul, Minn.

Use of the Cumulative Curve for
FOUNDRY SAND CONTROL

By R. E. Morey and H. F. Taylor,
Steel Castings Section, Division of Physical Metallurgy,
Naval Research Laboratory, Washington, D. C.

• The purpose of this investigation was to develop a technique for adequate evaluation of particulate raw materials in foundry use—sands, clays, silica flour, and refractories. Additional work was undertaken at the Naval Research Laboratory subsequent to the presentation of the original paper at the 48th Annual Meeting of A.F.A., Buffalo, N. Y., April 26, 1944. The present complete report should serve to open further lines of investigation to improve foundry material control.

IT IS BELIEVED that the present A.F.A. method of classifying molding sands does not give an adequate evaluation of their suitability as molding materials. Two sands, which are identical according to the A.F.A. classification, may show entirely different molding characteristics. Moreover, castings produced in one sand will be sound and of good quality, whereas castings produced in the other sand will contain porosity and have inferior surfaces.

This is why it is often impossible to obtain check results between foundries supposedly using the same grade of sand, and why inconsistent results are often obtained in a single foundry purchasing batch lots of sand from a single producer.

The problem, therefore, consisted of investigating methods of classifying sands and sediments which are used in other fields, to determine if they would help to overcome the deficiencies of the A.F.A. method; also, to modify and adapt the best of these methods to the grading of foundry sands and clays to the end that simple, accurate specifications could be developed for their purchase or designation as well as for their control.

A satisfactory method should encourage development of knowledge in the silt-clay region, permit more accurate control of sand mixtures and raw materials, and permit the interchange of ideas on a more accurate and scientific basis.

General Considerations. The present A.F.A. method of determining sand fineness is based on the determination of clay by settling and decantation to remove the particles which settle at a rate of less than one in. per min., and separation of the grains which remain in a nest of sieves arranged so that the coarsest sieve is at the top of the stack.

The sieves must be of certain sizes and must meet rigid specifications. The fractions retained on the various sieves are then multiplied by factors, as shown in Table 1, to obtain the A.F.A. fineness number.

This test in its present form has several faults. At the fine end only one point is determined, which is the 20-micron separation. This is not a measurement of size but of the percentage of the material coarser or finer than 20 microns. Material finer than this size is called A.F.A. clay, but it could be nearly all fine silt composed of fine silica particles and actually contain very little active clay.

The directions for making this test are not entirely clear on what

Table 1

SAND FINENESS—WITHOUT SILT OR CLAY

Sieve	Retained, per cent	Multiplier	Product
6	0.10	3	0.30
12	1.20	5	6.00
20	5.60	10	56.00
30	6.28	20	125.60
40	16.72	30	501.60
50	17.76	40	701.40
70	9.68	50	484.00
100	4.30	70	301.00
140	2.00	100	200.00
200	1.44	140	201.60
270	1.04	200	208.00
	66.12		2785.50

A.F.A. Fineness No. $= \frac{2785.50}{66.12} = 42.12$

Table 2

SAND FINENESS—WITH SILT BUT WITHOUT CLAY

Sieve	Retained, per cent	Multiplier	Product
6	0.10	3	0.30
12	1.20	5	6.00
20	5.60	10	56.00
30	6.28	20	125.60
40	16.72	30	501.60
50	17.76	40	701.40
70	9.68	50	484.00
100	4.30	70	301.00
140	2.00	100	200.00
200	1.44	140	201.60
270	1.04	200	208.00
Silt (53-20 mu)	7.48	300	2244.00
	73.60		5029.50

A.F.A. Fineness No. $= \frac{5029.50}{73.60} = 68.36$

Table 3

SAND FINENESS—WITH SILT AND CLAY

Sieve	Retained, per cent	Multiplier	Product
6	0.10	3	0.30
12	1.20	5	6.00
20	5.60	10	56.00
30	6.28	20	125.60
40	16.72	30	501.60
50	17.76	40	701.40
70	9.68	50	484.00
100	4.30	70	301.00
140	2.00	100	200.00
200	1.44	140	201.60
270	1.04	200	208.00
Pan	33.88	300	10164.00
	100.00		12949.50

A.F.A. Fineness No. $= \frac{12949.50}{100.00} = 129.50$

is to be included in the silt-clay region. Some fineness analyses are made including the clay in the computations, while others are computed on the basis of grain material only. Some include silt but not clay. The former method naturally produces a much higher fineness number.

Tables 1 to 3, inclusive, show the computation of the A.F.A. grain fineness number in various ways. When the A.F.A. fineness number is found it gives a general idea of the size of the sand if one is familiar with the numbers, but they have little relation with any actual dimensions, and they show very little about the character of the sand.

The extensive bibliography of methods for particle size determination indicates the large amount of information in this field. Some of the more pertinent articles are discussed very briefly in the following to furnish a background for the techniques described later.

Krumbein[30] describes the history and progress of mechanical analysis from the decantation methods of ancient Greece to modern techniques. According to Krumbein, sieves were first used in 1704. In 1784 sedimentation was used for separation of a sediment into three grades, and in 1805 sieving and decantation were combined in a single technique. Elutriators were used in 1839. Stokes' law was formulated in 1851 and was applied to mechanical analysis in 1867.

The use of graphs to represent sediments was started in 1892, as well as the use of the centrifuge in mechanical analysis. Air analyzers were introduced in 1906 and the continuous sedimentation balance in 1912. Methods using a manometer were introduced in 1918, the pipette method in 1922 and the hydrometer in 1927. A bibliography of 186 articles is included as well as sketches of some of the early apparatus.

Dallavalle[16] has collected a large amount of material in his book, *Micromeritics*. Chapter 3 on "Shape and Size Distribution," Chapter 4 on "Methods of Particle Size Measurement," Chapter 5 on the "Theory of Sieving and Grading of Materials" and Chapter 6 on "Characteristics of Packings" are of particular interest to the foundryman. This is an excellent source of fundamental statistical information.

Sieve Systems

Investigators, in general, agree on measuring the clay sizes first, then removing the clay and analyzing the grain in a set of sieves. Several sets of sieves have been made which are satisfactory, the two most widely used in this country being the National Bureau of Standards and the Tyler systems.

In these series each sieve varies in a definite manner from the next in size; that is, the linear dimensions along one side of the square openings multiplied by a constant gives the linear dimensions of one side of the opening in the next larger sieve. Dallavalle[16] discusses various sieve series in Chapter 5 of his book.

Cumulative curves[59, 60] can be used effectively to represent sand size and distribution. A cumulative curve is simply a graph, usually having particle size as the abscissa and percentage of material retained as the ordinate.

Curves Defined

They are called cumulative curves because the sieves are usually placed in sets or stacks, and to find the percentage coarser than any particular sieve the amounts retained on the sieve and on all the coarser sieves must be added together. This distinguishes it from the size frequency curve in which only the amount retained on each sieve is plotted against size. Figure 1 shows a typical cumulative curve.

Analysis of the finer parts of sediments has been made in several ways. Trask[59, 60] used a centrifuge. Bouyoucos[5–12] and Casagrande[13, 14] used hydrometers. Robinson[51], Krauss[29] and Jennings[23] developed the pipette method independently. Krumbein[30, 31], the ASTM[1], and Jackson[22] have discussed the use of the pipette.

Methods Described

Oden[44] describes the use of manometers and specific gravity balances as well as the use of a continuous sedimentation balance which weighs the sediment as it accumulates on a submerged pan. Hellman and McKelvey[21] describe an interesting combination of pipette and hydrometer which utilizes the best features of each.

Thoreen[58] discusses the hydrometer method in considerable detail with a very clear explanation of the underlying principles. The hydrometer method is based on the fact that when a sample of material, such as a molding sand, is mixed with water, it increases the density of the resulting suspension.

When the suspension is allowed to stand, the particles settle out according to Stokes' law and the density of the suspension gradually approaches the density of the suspending medium. The amount of material in suspension at any time at the location of the hydrometer bulb is found from the hydrometer reading and the size is found by

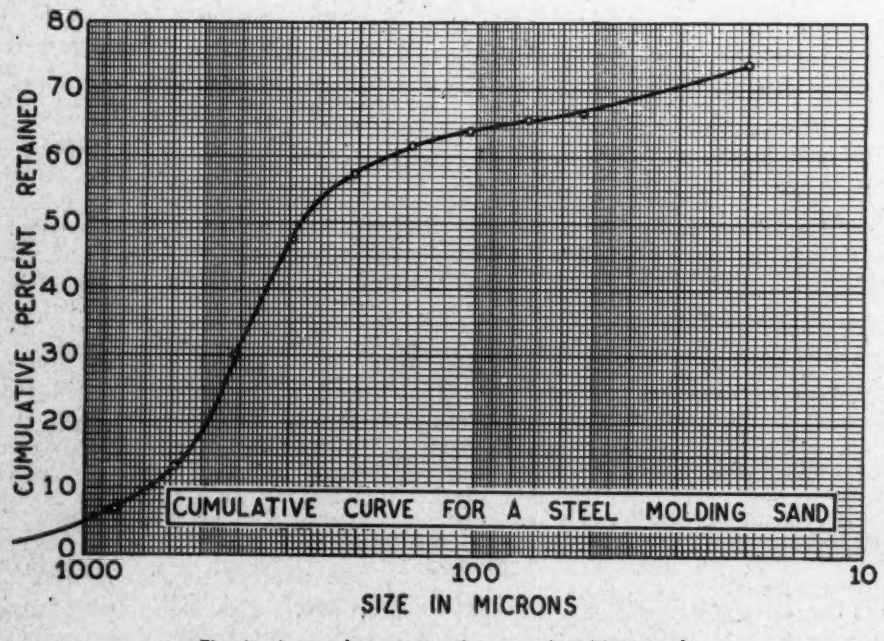


Fig. 1—A cumulative curve for a steel molding sand.

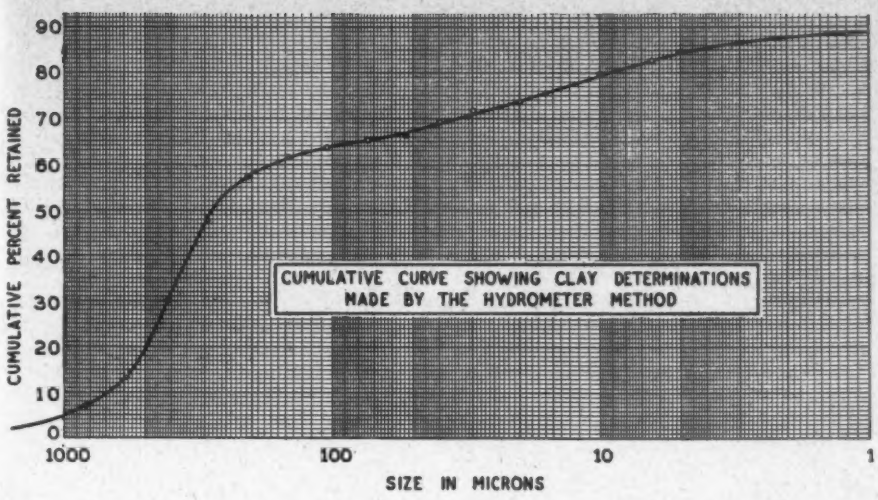


Fig. 2—Cumulative curve showing clay determinations made by the hydrometer method.

using the depth of the bulb and the settling time in the Stokes' law equation. The details are discussed later.

The hydrometer procedure used by the Department of Agriculture, Bureau of Public Roads, is described by Wintermeyer, Willis and Thoreen[64]. Willis, Robeson and Johnson[63] describe a graphical method of correcting the data, and Barber[4] developed a slide rule for making the corrections.

When many of these articles have been carefully read some salient facts appear:

a. The difficulties of the foundryman in the study of sand are no different from those of the oil man, the road builder or any other user of particulate materials sediments.

b. A great amount of work has been done by workers in allied fields on the determination of particle sizes and their representation.

c. Methods have been developed by them which are faster and produce more information than the method developed and standardized several years ago by the A.F.A.

d. It would be well to modify foundry sand laboratory methods for two reasons; first, to save time, and second, to get more information about our sands and thus lay the foundation for more accurate control and, therefore, better castings at lower cost.

Experimental Work. In order to evaluate the convenience and utility of methods cited in the foregoing and in the appendix, it was decided to try some of the more promising methods at the Naval Research Laboratory.

The first method to come under scrutiny was the pipette method described by Jackson[22]. He used a 50-gram sample of dried sand which is added to a solution made up of 475 ml. of distilled water and 25 ml. of a 3 per cent solution of NaOH.

This mixture is then dispersed with an electric stirrer mounted on a mason jar with baffles. The mixing period is 5 min. The sample is then transferred to a graduate and distilled water added to make one liter. The graduate is up-ended several times to place all the sand and clay in suspension, after which it is placed on a table and a stop watch started.

At some time after the beginning of the sedimentation period, which is determined by the size of separation wanted and the temperature of the suspension, a 25-ml. pipette is inserted into the liquid to a depth of 5 in. and a sample removed and placed in a weighed evaporating dish.

The sample is then evaporated to dryness and reweighed, the weight of dry clay plus NaOH is determined by difference and the weight of NaOH is subtracted, leaving the weight of clay in the pipette sample. Multiplying this amount by 80 gives the percentage of material finer than the size for which the test was made.

A nomographic chart (Fig. 14) from Jackson's work[22] is included in this report, which allows the settling time to be determined readily from the temperature and the size of separation desired. This method has been used successfully for several years at the Naval Research Laboratory, but is not entirely satisfactory.

It requires a sensitive analytical balance to weigh the evaporating dishes. The evaporating dishes are cooled in a desiccator after drying and, during weighing, begin to absorb moisture from the air, making weighing difficult. This can be overcome by using covered weighing dishes. The ground glass covers are closed when the sample is removed for weighing, and this eliminates the absorption of water and increases accuracy.

This method is time consuming and tedious if many determinations

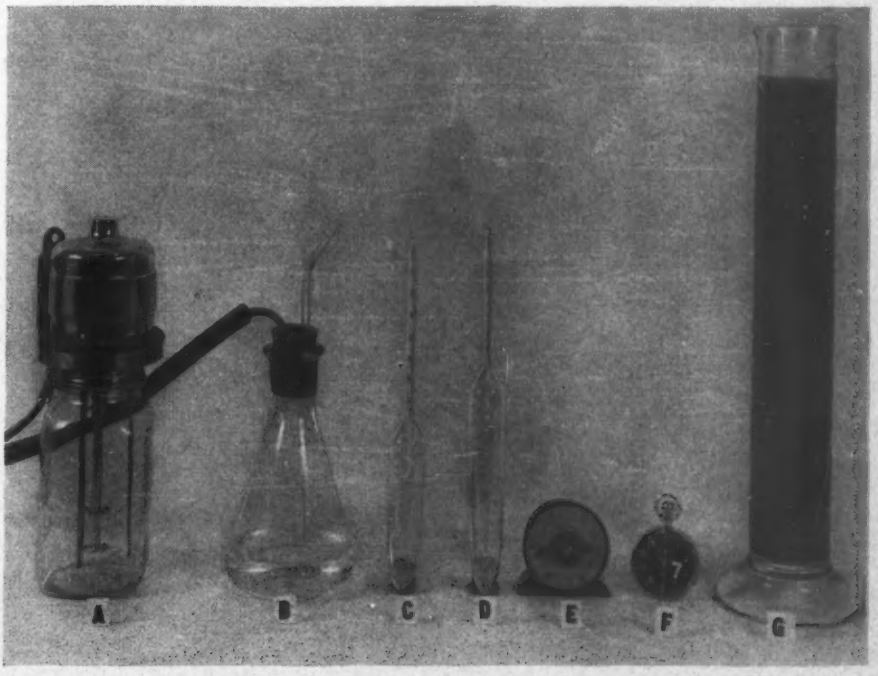


Fig. 3—Equipment used for sand particle size determination by the hydrometer method.

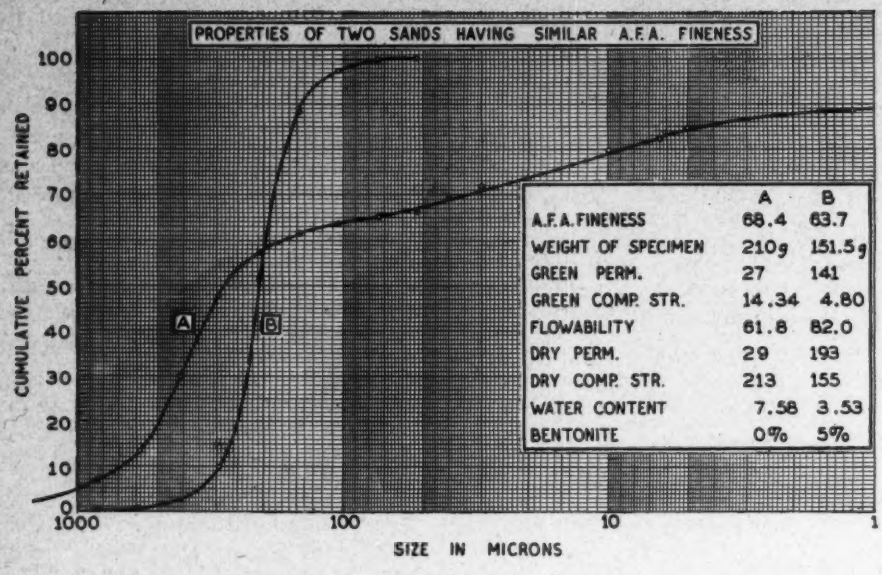


Fig. 4—Cumulative curves for two sands having similar fineness numbers but with physical property variations.

are required. It has one important advantage over the A.F.A. method in that determinations may be made at several sizes, thus providing data for cumulative curves in the clay region. This is important because it is due to the material in this region (less than 50 microns) that sand troubles often develop.

During the time the pipette method was in use, the practice of plotting sieve data as cumulative curves was adopted, and proved so much superior to the histograms previously used that they are now employed exclusively. A typical plot, sometimes called a "weight accumulation curve," is shown in Fig. 2.

Advantages of Method

Krumbein[33] has discussed the advantages and significance of this method. Trask[59] used it in his study of sediments in connection with the search for oil-bearing deposits. The median and quartile values used by Trask, as well as his method of determining distribution and skewness, are of considerable interest and are similar to methods described by Morey and Taylor[42] even though their methods were developed without knowledge of the previous work of Trask in the petroleum field.

Briefly, Trask's method is to plot his data on semi-log graph paper as a cumulative curve using "per cent retained" as ordinate and particle size as abscissa. The particle sizes at which the curve crosses the 25, 50 and 75 per cent retained lines are then read from the abscissa (usually in microns).

These points are called the first quartile, median size and third quartile. The median size is a very useful measure of particle size since 50 per cent by weight of the grains are larger and 50 per cent are smaller than this value. Morey and Taylor[42] called this "center grain size."

Trask, and Morey and Taylor, both used the ratio of the size of the first quartile to that at the third as a means of representing distribution, and Trask went a step further in taking the square root of this ratio which he calls coefficient of sorting:

$$So = \sqrt{\frac{Q_1}{Q_3}}$$

Q_1 and Q_3 being the grain size at the first and third quartiles, respectively. This is illustrated in Fig. 7.

Trask's formula for coefficient of skewness, *Sk*, is:

$$Sk = \frac{Q_1 \times Q_3}{M_2}$$

This represents the ratio of the slope in the second quartile interval to that in the third quartile interval. If *Sk* is 1, the sand has a normal distribution. If *Sk* is less than 1, the sand is skewed to the left and if greater than 1, the sand is skewed to the right. If a sand is skewed to the left it means that the mode, or maximum concentration of particles lies to the left of the median or to the coarse side and vice versa.

Trask shows that a skewness coefficient of 0.67 and 1.50 represent the same amount of divergence of the mode from the median but in opposite directions. In order to avoid any erroneous impression from this fact he uses the logarithm of the coefficient of skewness. The log of 0.67 is minus 0.18 and the log of 1.50 is plus 0.18.

Thus, instead of varying about unity the logarithms vary about zero, negative values indicating skewness to the left and positive values to the right. Trask's data[59] (Table 6, pp. 292-295), show the quartiles Q_1, M and Q_3, the coefficient of sorting, *So*, the coefficient of skewness, *Sk*, and log skewness, *Log Sk*. He classified particle size of sediments as follows:

Larger than 1000 microns....gravel
From 50 to 1000 microns.....sand
From 5 to 50 microns.....silt
From 1 to 5 microns.....clay
Smaller than 1 micron
.....colloidal clay

This is a very logical nomenclature and might prove to be useful for foundry terminology.

From Trask's data it is possible

Table 4

DATA REPORTED BY TRASK IN STUDY OF SEDIMENTS

Sample	*143B*	*174A*	*207A*	*270A*	*338*	*377*	*405*	*467*	*484*
Q_1	115	9.5	13	215	15	225	60	550	28
M	16	5.8	5.5	150	4.8	180	25	190	6.6
Q_3	5	1.6	1.1	62	1.3	80	3.7	48	1.8
So	4.80	2.44	3.44	1.86	3.30	1.70	4.04	3.38	3.94
Sk	2.25	0.61	0.47	0.59	0.85	0.56	0.36	0.73	1.12
Log Sk	0.35	—0.22	—0.32	—0.23	—0.07	—0.26	—0.45	—0.14	0.05
Gravel	4	0	0	11	Trace	0	Trace	11	0
Sand	28	2	10	68	3	81	29	63	15
Silt	43	48	46	6	45	10	40	9	42
Clay	25	35	23	7	34	7	26	15	29
Colloid	0	15	21	8	18	2	5	2	14

Table 5

STATISTICAL DATA ON STEEL FOUNDRY SANDS

Sample	*A*	*B*	*C*	*D*
Q_1	700	293	217	131
M	475	242	186	109
Q_3	338	210	152	90
So	1.44	1.18	1.195	1.206
Sk	1.05	1.05	0.953	0.993
Log Sk	0.021	0.021	—0.021	—0.007
Gravel	8	0	0	0
Sand	92	100	100	98
Silt	0	0	0	2
Clay	0	0	0	0
Colloid	0	0	0	0

to reconstruct cumulative curves to show the texture of his samples. Some of these are shown in Figs. 8 to 10. These curves also serve to illustrate the variety of sediments as they occur in nature. Trask's values are shown in Table 4.

Figure 11 shows some of the sands used as a base for steel molding sand mixtures. Statistical data on these sands are shown in Table 5. Comparing these curves with Figs. 8 to 10 shows at once the outstanding differences between natural deposits and washed and graded sands.

While the median size may be similar, the distribution, or sorting, has been changed considerably in the washing and sorting process, one sand deposit being sorted into four or more grades of sand in addition to the gravel and silt, most of which is discarded.

In examining these curves in detail we note that they cover most of the range of sand fineness which is commonly used in steel molding sand mixtures. The sizes range from 109 to 475 microns. The coefficients of sorting are all below 1.50, which indicates that the materials are extremely well sorted when compared with the normal sediments (Figs. 8 to 10) which have sorting coefficients as high as 4.80.

These skewness coefficients range from 1.05 to 0.95, which indicates relatively little skewness. Visual examination shows the curves to be symmetrical with no abnormalities.

Interesting in connection with the discussion of skewness are the sands shown in Fig. 12. They are steel molding sands which have been through a reclamation installation, the coarse sand being reclaimed sand which is normally rebonded and used over and the finer sand is the portion normally discarded as fines.

The similarity, illustrated in Fig. 13, of the fine sand to Albany sand was noted and, to determine if it would serve the same purpose, the material was bonded with a small amount of bentonite and dextrine and used to make a brass casting. It produced very good results and with a little development would probably make a good sand for light work in any metal except, possibly, magnesium.

The curves themselves show considerable skewness in opposite directions. This is the result of a fairly efficient "split" or separation in the hydraulic separating unit. The coarse fraction contains more than half of the grain material and comprises the "toe" of the curve before the separation was made. It is skewed slightly to the right.

The fine portion is skewed to the left and contains that material which formed the shoulder of the cumulative curve prior to separation. It is surprising to note that this material, believed to be worthless fines with a very large amount of inert clay, actually has only 21 per cent silt and less than 3 per cent clay. The remaining 76 per cent is good grain material.

After Jackson's method was used for some time to make a 20-micron determination, the need was felt for more points on the cumulative curve in the fine end, so the pipette method was used for other sizes as well, using the nomographic chart in Jackson's[22] paper and reproduced here as Fig. 14.

Determinations were usually made at 10, 5 and 2 microns. The results produced were good but the work

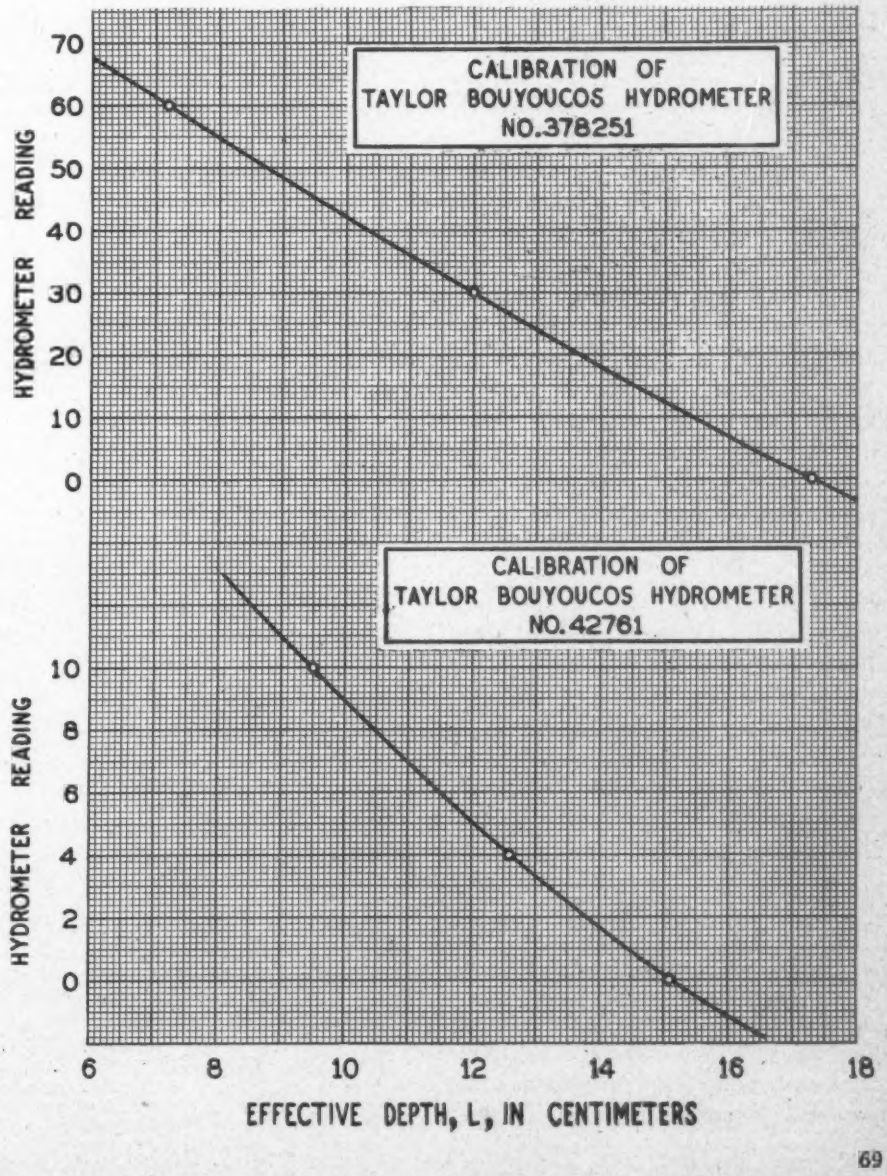


Fig. 5—Hydrometer calibration curves.

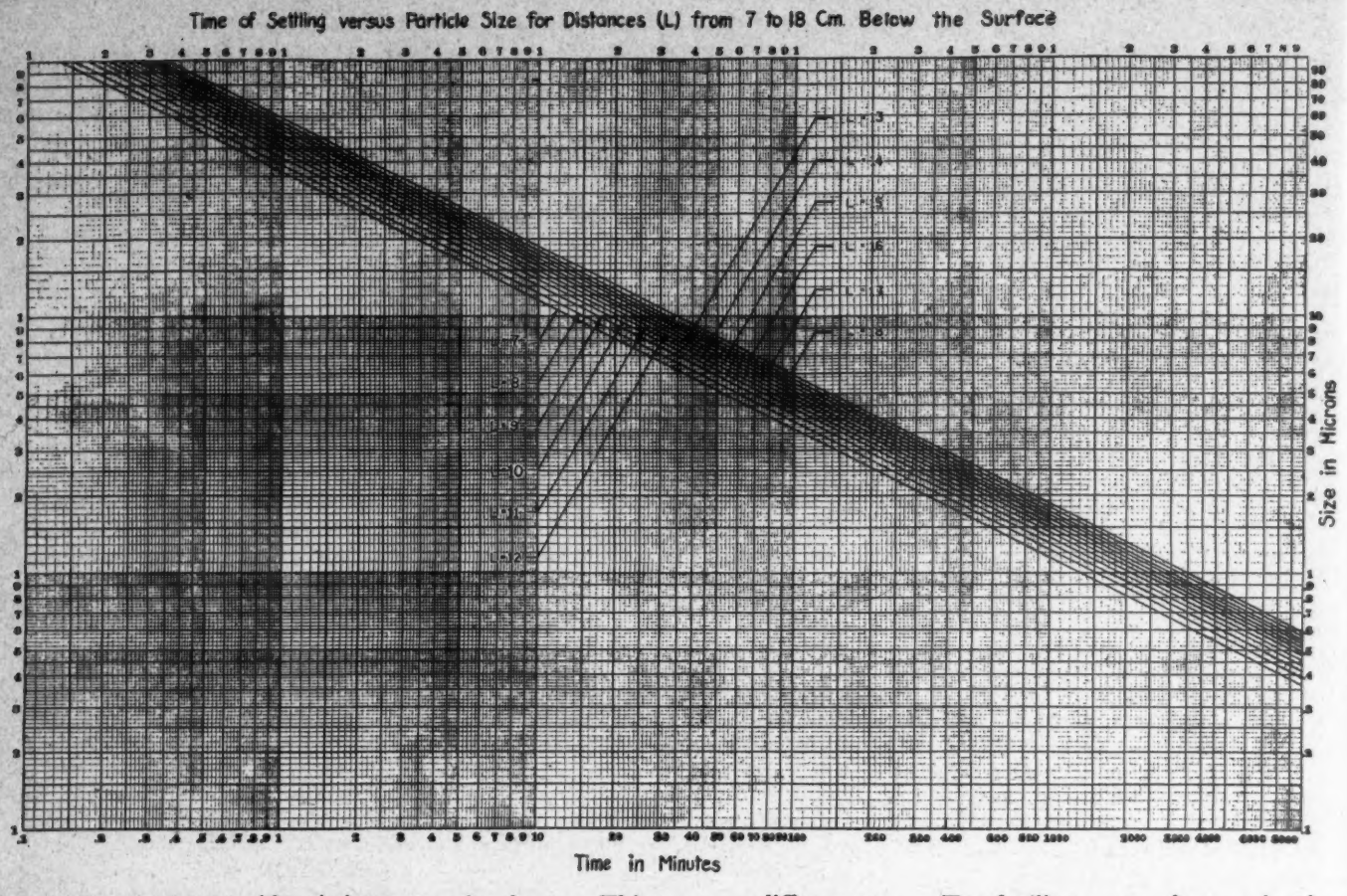


Fig. 6—Chart used to simplify calculations, showing relationship between settling time and particle size for various distances below surface.

was very tedious and time consuming if many points were to be determined. To simplify testing, several hydrometers were obtained and tried for the determination of clay.

It soon became apparent that a hydrometer for this purpose would have to be very sensitive. A Bouyoucos hydrometer was obtained and his method[5-12] was tried. His directions include determinations at 50, 5 and 2 microns. The agreement with the pipette method at 50 and 5 microns was good, but at 2 microns results did not check. It was then decided to investigate some of the more precise methods.

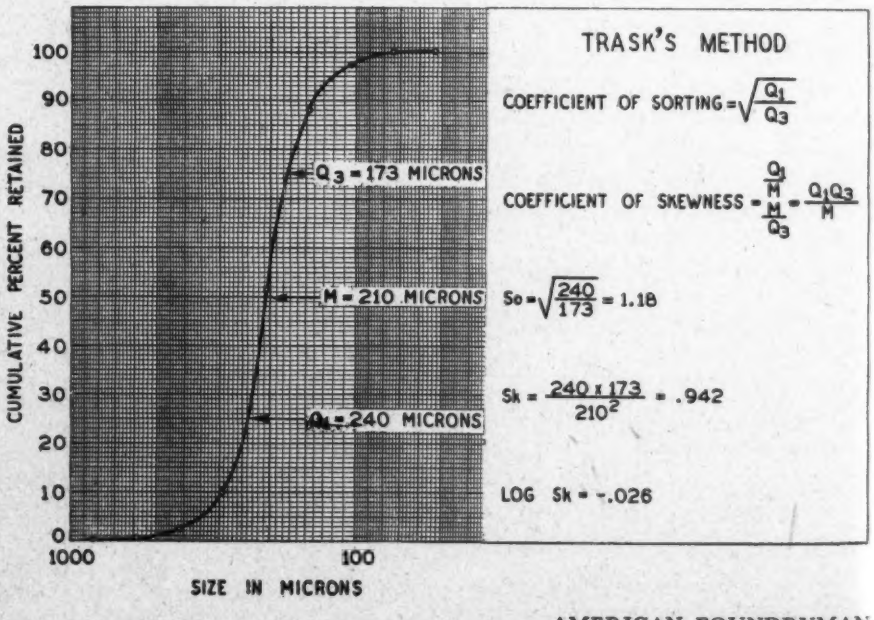
The method of the Bureau of Public Roads[64, 58, 4] was tried and found to give very rapid results. The equipment used in this method is shown in Fig. 3. Considerable care is needed in maintaining constant temperatures.

When the hydrometer is placed in the suspension it does not always float at the same height. As the particles settle toward the bottom, the remaining suspension becomes less dense and the hydrometer settles deeper. This causes a difference in the depth of settling which is used in the calculations. This consideration is discussed in detail later.

Briefly, the technique for using this method is as follows: 50 grams of dry sand is weighed and transferred to an electric stirrer. Five hundred ml. of distilled water and 5 ml. of normal sodium (meta) silicate solution is added. This is stirred for 5 min. and transferred to a one-liter cylindrical graduate.

To facilitate transfer, a bottle filled with distilled water is used having a connection to the compressed air line, a vent, and a jet. When the bottle is picked up, placing one finger over the vent causes air pressure to build up inside and a long thin stream of water to flow from the jet which quickly washes all material from the stirring cup

Fig. 7—Trask's method[20] for particle size distribution determination.


TRASK'S METHOD
COEFFICIENT OF SORTING = $\sqrt{\frac{Q_1}{Q_3}}$
COEFFICIENT OF SKEWNESS = $\frac{\frac{Q_1}{M}}{\frac{M}{Q_3}} = \frac{Q_1 Q_3}{M}$
Q_3 = 173 MICRONS
M = 210 MICRONS
Q_1 = 240 MICRONS
So = $\sqrt{\frac{240}{173}}$ = 1.18
Sk = $\frac{240 \times 173}{210^2}$ = .942
LOG Sk = -.026
CUMULATIVE PERCENT RETAINED
SIZE IN MICRONS

to the graduate. Distilled water is then added to make one liter.

The graduate is placed in a constant temperature tank (desirable but not essential) at 67° F. When it is at temperature, the graduate is removed and up-ended until all material is in suspension and well mixed. It is then returned to the constant temperature bath and a stop watch is started. Up to this point the method is very similar to Jackson's except that a different deflocculant is used.

When the cylinder has been returned to the tank and the timer started, the hydrometer is inserted and the first reading taken as soon as it comes to rest. The hydrometer is read at the top of the meniscus because the suspension is not transparent, but the error introduced is slight and is roughly balanced by the effect of the sodium silicate used as a deflocculant. Usually the first reading can be made within 30 sec.

Successive readings are then taken at intervals to give the number of determinations desired. The hydrometer readings and corresponding settling times are then used to determine percentages[58] and size in two separate steps by means of the following formulas:

$$P = \frac{(R \text{ plus } \Delta R)\ a \times 100}{W}$$

where

P = Percentage of originally dispersed sample remaining in suspension.

R = Hydrometer reading.

W = Weight of sample.

ΔR = Correction of hydrometer reading for variation in temperature from 67° F.

a = Correction coefficient for variation in specific gravity from 2.65.

and

$$d = \sqrt{\frac{30\ nL}{980\ (G - G_1)\ T}}$$

where

d = Maximum grain diameter in millimeters in suspension at any given time after dispersion.

n = Coefficient of viscosity of the suspending medium, in poises.

L = Average distance in centimeters through which particles settle in a given time period.

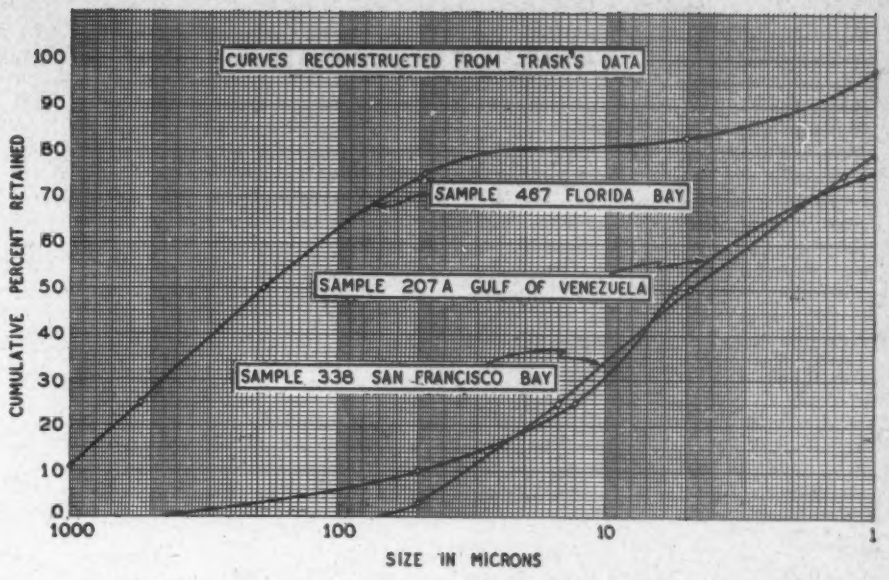


Fig. 8—Cumulative curves reconstructed from Trask's data[59] showing texture of samples (see Figs. 9 and 10).

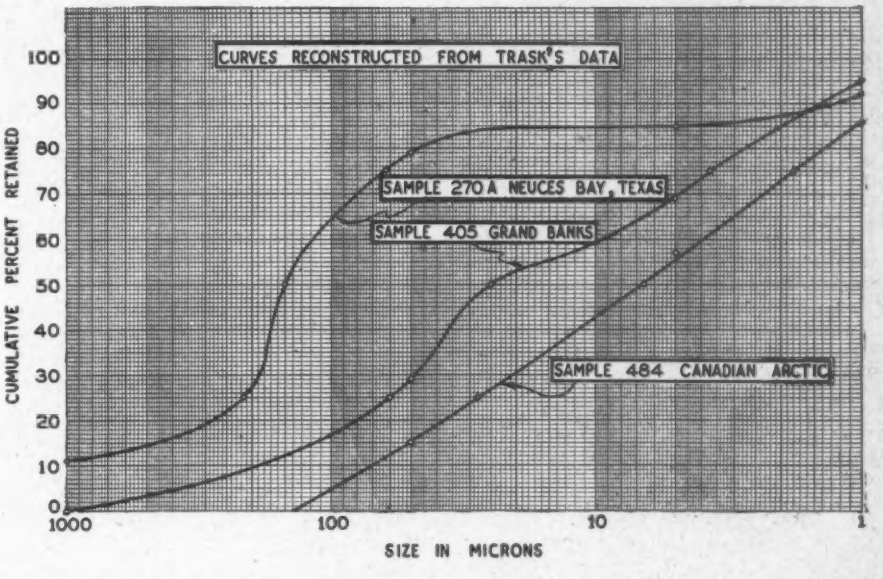


Fig. 9—Reconstructed cumulative curves of other samples from Trask's data (see Figs. 8, 10).

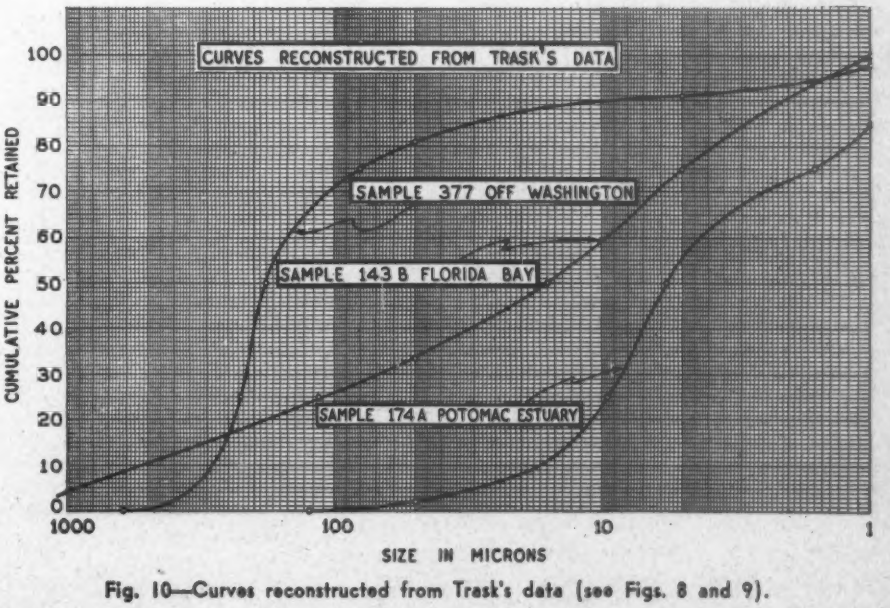


Fig. 10—Curves reconstructed from Trask's data (see Figs. 8 and 9).

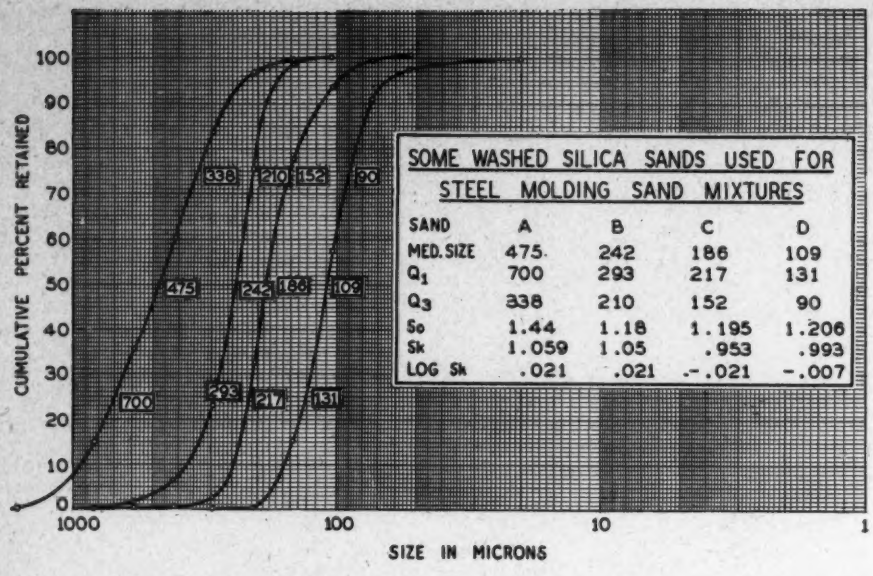

SOME WASHED SILICA SANDS USED FOR STEEL MOLDING SAND MIXTURES
SAND A B C D
MED. SIZE 475 242 186 109
Q1 700 293 217 131
Q3 338 210 152 90
So 1.44 1.18 1.195 1.206
Sk 1.059 1.05 .953 .993
LOG Sk .021 .021 -.021 -.007
CUMULATIVE PERCENT RETAINED
SIZE IN MICRONS

Fig. 11—Distribution curves for washed and graded sands. Comparison with Figs. 8, 9 and 10 shows outstanding differences from natural deposits.

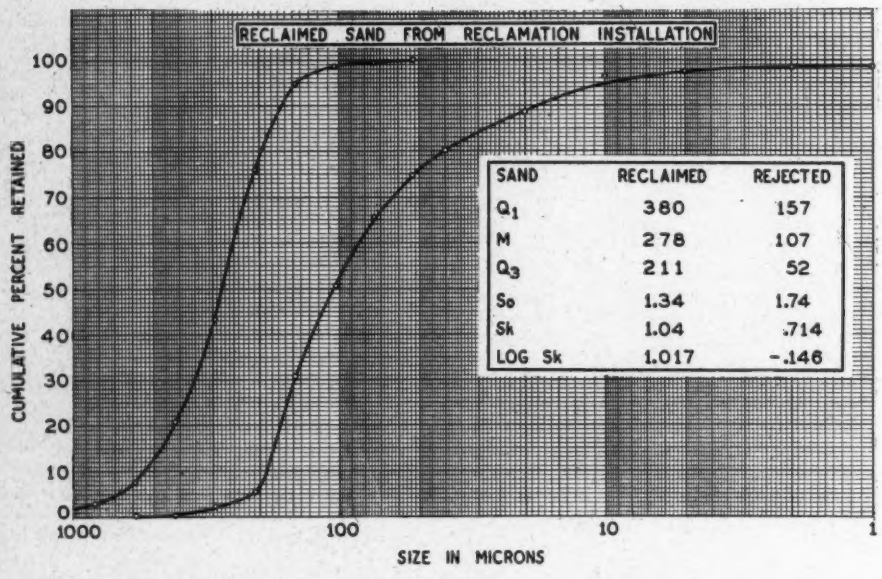


Fig. 12—Curves for steel molding sands from reclamation installation.

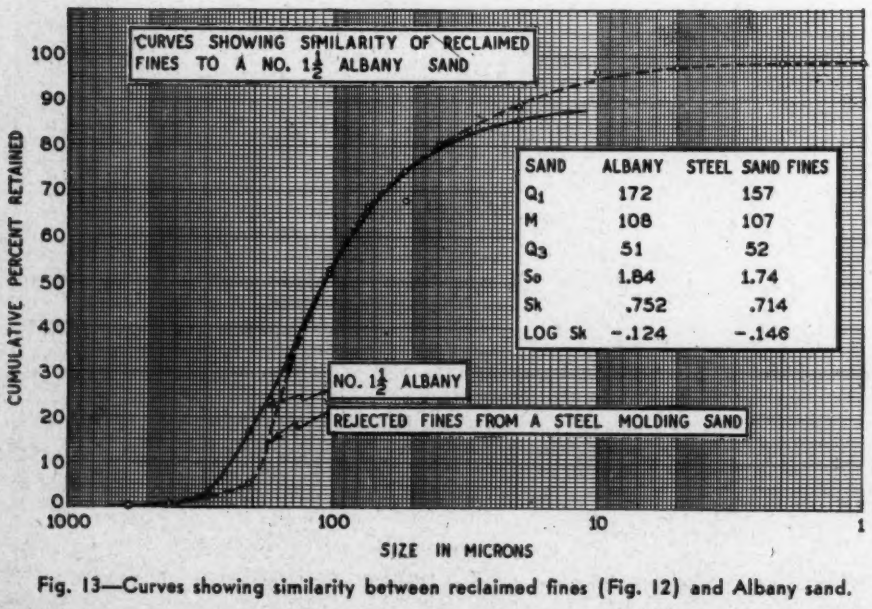

CURVES SHOWING SIMILARITY OF RECLAIMED FINES TO A NO. 1½ ALBANY SAND
SAND ALBANY STEEL SAND FINES
Q1 172 157
M 108 107
Q3 51 52
So 1.84 1.74
Sk .752 .714
LOG Sk -.124 -.146
NO. 1½ ALBANY
REJECTED FINES FROM A STEEL MOLDING SAND
CUMULATIVE PERCENT RETAINED
SIZE IN MICRONS

Fig. 13—Curves showing similarity between reclaimed fines (Fig. 12) and Albany sand.

T = Period of sedimentation in minutes.

G = Specific gravity of particles.

G_1 = Specific gravity of the suspending medium.

If a constant temperature tank at 67° F. is used ΔR may be omitted, and if the specific gravity is near 2.65, as in the case of most of the sands used for molding, "a" may be omitted. W is usually 50 so the first formula reduces to $P = 2R$, that is, the reading of the Bouyoucos hydrometer is multiplied by two.

In the second formula, if T is held at 67° F., n is 0.0102 poise, G is 2.65 and G_1 is 0.99841. The formula, therefore, reduces to:

$$d = \sqrt{\frac{30 \times 0.0102 \times L}{980\,(2.65 - 0.99841)\,T}}$$

$$= \sqrt{\frac{0.000189\,L}{T}}$$

If d is desired in microns instead of millimeters,

$$d = \sqrt{\frac{198\,L}{T}}$$

L must be determined for each hydrometer. When employing a Bouyoucos hydrometer Thoreen[58] uses 0.42 of the immersed depth, and for the specific gravity type hydrometer a value equal to the depth from the free surface to the center of the submerged volume. It is believed that the latter method is better in either case.

Hydrometer Method Procedure

This distance may be found by filling a cylindrical graduate partly full of water, reading the volume, inserting the hydrometer to some particular hydrometer value, reading the volume on the graduate again, and then withdrawing the hydrometer until the water level on the graduate goes halfway down to the first reading. Hold the hydrometer at this position and measure the distance in cm. from the water surface to the particular hydrometer reading which was selected.

This distance is the L corresponding to that reading. If three or four such points are determined for each hydrometer a curve may be drawn, giving L as a function of the reading. Figure 5 shows this relation for two of the hydrometers used at the Naval Research Laboratory.

In order to simplify calculations a chart was made to show the re-

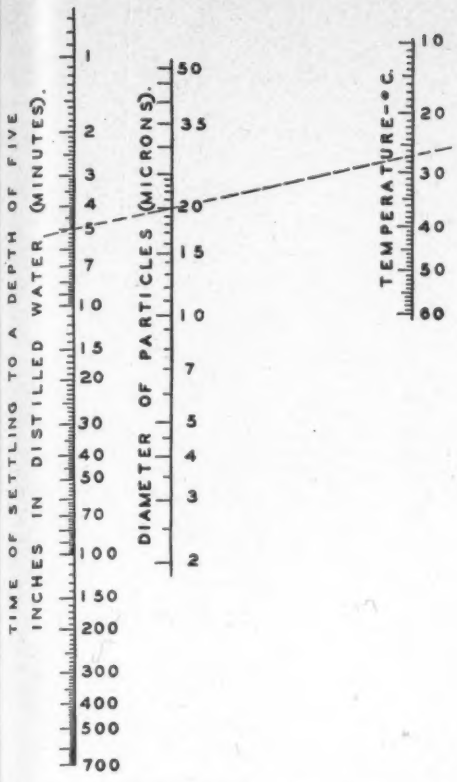


Fig. 14—Nomographic chart from Jackson's[22] method used to show temperatures, settling time, and particle size relationship.

lationship between T, L and d. It is shown as Fig. 6 and is derived from Stokes' law[58].

By using the two charts the hydrometer method becomes very simple, consisting of the following steps:

a. Reading the hydrometer and the corresponding settling time.

b. Determining L from the curve for the hydrometer used (Fig. 5).

c. Using the settling time and L, determining the size in microns from the chart (Fig. 6).

d. Determining the percentage of material finer than the size in microns by multiplying the hydrometer reading by two.

e. When several points have been determined, the clay is siphoned off, the sample dried, and sieved in the usual way. The sample can be siphoned to a depth of 12 in. after settling 4 min. This is repeated until the suspension is clear after 4 min. The water is decanted, the grain dried, and sieved in the usual way.

f. A cumulative curve of the sieve data is plotted using the hydrometer determinations in the silt-clay range to complete the curve. If cumulative percentages retained are used, each hydrometer percentage must be subtracted from 100 to put them on the same basis.

A hydrometer of the type used by Hellman and McKelvey[21] was made and tried. It has the advantage that the sample may be withdrawn from any desired depth. L, therefore, is predetermined instead of variable. The density of the sample in the pipette is approximately constant, so any error which might be caused by variation in the density of the suspension from top to bottom of the hydrometer is eliminated.

If temperature variations are corrected, this makes a simple tool for rapid routine clay determinations, but from the tests conducted to date the regular Bouyoucos hydrometer and the technique described previously gives more consistent results.

Since the cumulative curve method, in conjunction with hydrometer analysis, has been in use at the Naval Research Laboratory, several varied uses have been made of it which are indicative of the many further applications which can be found as familiarity with the method develops. Some of the uses made to date are:

a. To give essential information on sands, particularly in the silt-clay region where mysterious troubles sometimes develop. Such troubles as are attributable to particle size can be immediately determined. More often than not such is the case if fairly standard brands of raw materials are used.

b. For specifying sands, silica flours, clays, blast grit, grinding compounds, and similar raw materials. This application has been limited because of the inability of the supplier to provide complete analyses. However, many times it has been possible to describe requirements in terms of materials previously supplied and to indicate use of longer or shorter grinding times or different sieve sizes, to obtain useful results. Acceptance of this method as standard practice for particular materials would simplify specifications.

c. Various grades of silica flour which perform differently in practice, have been checked, reasons for their differences readily disclosed, and correction made.

d. Many commercial products marketed as highly specialized materials have given up their secrets when examined by this method.

e. One of the latest applications has been in the study of the powdered refractory materials used for investment casting. It has been possible to synthesize mixtures, thereby reducing cost and eliminating purchase of seemingly strategic materials.

f. Figure 15 shows an interesting application in the study of removal of fines from a molding sand. It was necessary to test a machine for its ability to remove such fines and it was not possible to collect the material which was removed. Silica flour (Curve B) was added to heap sand (Curve A) to produce a mixture high in fines (Curve C). Curves D and E show the progressive re-

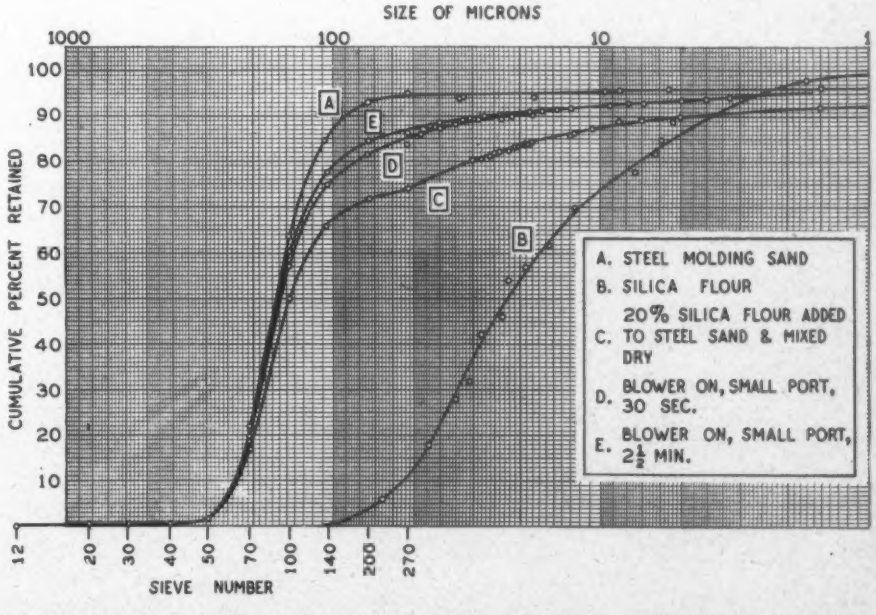

SIZE OF MICRONS
CUMULATIVE PERCENT RETAINED
SIEVE NUMBER
A. STEEL MOLDING SAND
B. SILICA FLOUR
C. 20% SILICA FLOUR ADDED TO STEEL SAND & MIXED DRY
D. BLOWER ON, SMALL PORT, 30 SEC.
E. BLOWER ON, SMALL PORT, 2½ MIN.

Fig. 15—Use of cumulative curves in test of machine for ability to remove molding sand fines.

moval of the fines with operating time. This is about the only technique which would accurately indicate the changing sand texture.

Conclusions

The use of cumulative curves at the Naval Research Laboratory for illustrating the particle size and distribution of foundry sands and clays has proved definitely superior to the A.F.A. grain fineness number ordinarily used for this purpose.

Sieve data for the coarser sand grains and the result of hydrometer analysis of the finer clay and silt are used in a single curve to give a comprehensive description of the material. This technique has proved particularly useful for specifying, controlling, and understanding foundry sands, clays, ladle refractories, silica flour and precision casting investments.

It is believed that the present standard A.F.A. grain fineness method does not give sufficient information about sands, and that it should be replaced by the methods described in this report. This would permit more accurate control of molding sand mixtures, simplify the selection and specification of molding sands and similar foundry raw materials, and permit the interchange of information on a more accurate and scientific basis.

It is recommended that consideration be given the possibility of developing specifications for foundry sands and other particulate materials on the basis of cumulative curves determined in the described manner, or in some equally accurate manner.

There is great need for the development of more precise information concerning clays as this is definitely the missing link in sand specification and control. While the hydrometer method gives a concise picture of particle size, more must be known about the nature of clays before their behavior in the foundry can be understood or improved materially.

Acknowledgment

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REFRACTORIES

Ferrous Foundry Electric Melting

(Continued from Page 60)

sion and poor spall resistance. Silica fails to meet the requirements for the same reason.

Fireclay refractories fail in cold melting because of their wide softening range and poor chemical resistance. In duplexing operations, superduty fireclay products often do a very excellent job, and in some instances do a fair job where cold melting is practiced.

Most operators have found that sillimanite or mullite types of refractories give the best and most economical service in the long run. Their high melting point without a wide softening range, plus their exceptional resistance to spalling, coupled with better than usual resistance to fluxing, make them most fitted for this application.

Even so, some operators find that it pays to balance out the lining life by the use of silicon-carbide refractories as door blocks. Some also use aluminum-oxide refractories for electrode sleeves, but the advantage of this is debatable.

Zircon refractories are now being used as linings in the indirect-arc rocking furnace. The application has been limited so far, but the results are quite encouraging. They are extremely refractory, but the resistance to spalling is somewhat lower than that of sillimanite or mullite.

This factor is overcome by using sillimanite door shapes. With this combination it appears that double lining life is assured. Since the cost of zircon is approximately twice that of sillimanite, the principal saving is in the cost of labor and a reduced number of shut downs for relining.

More development work is necessary before one can be assured that zircon will be the most economical lining for the indirect-arc rocking furnace in all ferrous melting operations; where lining life is not satisfactory it would certainly be worth investigating.

REFRACTORIES TO HOLD "INFORMATION PLEASE"

One of the features of the Refractories Session at the 50th Anniversary Convention will be an "Information Please" program. Several foundrymen and metallurgists with long experience in the use of refractories have agreed to serve on a question and answer panel and they will do their best to answer your questions.

In order for them to be of the greatest service to you, the committee would appreciate your sending in your questions now. These questions should be sent to Chairman C. E. Bales, A.F.A. Refractories Committee, Box 124, Ironton, Ohio.

Skin drying a mold with single-unit propane-gas torches of steel tubing construction.
(Courtesy, Sumner Iron Works, Everett, Wash.)

Sand Mold Drying with Propane-Gas Torches

By Frank C. Rogers,
Superintendent, Olympic Steel Works,
Seattle, Wash.

IN producing a mold surface capable of resisting the tenacious characteristics of molten steel, several factors must be considered. Steel at 3000° F. is by no means passive in its action towards mold surfaces. Variables affecting these factors are many, and are, naturally, a function of the individual processes employed by the separate foundries. Foundrymen will undoubtedly concur in the fact that the control of all of these variables at any one time is a problem of no small magnitude. But it is the constant effort of foundrymen to control these variables that is resulting in a better and more useful product.

Undoubtedly the methods of producing molds are as numerous as the foundries themselves, but all can be generally classified as green sand, skin-dried or oven-dried molds. The conception, in this vicinity, of these three classifications is as follows:

Green Sand: The moisture content of the whole mold is from 1½ to 4 per cent.

Skin Dried: The surface of the mold has been dried to a depth of ¼ to 2½ or 3 in., depending on the size of the mold.

Oven Dried: The whole mold has been dried by placing in an oven and nearly all moisture removed.

The discussion at hand concerns the skin-dried mold procedure mainly in connection with the methods of drying.

The diesel torch, involving the use of compressed air, has been in general foundry use in the Northwest area as the means of applying heat to mold surfaces. Out of this experience, steps were taken to design and develop a torch utilizing propane gas for fuel. The designer's first approach to the foundrymen of the Northwest was received with much interest, and their aid was enlisted in the development of the castings for a torch using propane gas by itself.

It was found that this torch had two distinct disadvantages: (1) it was too heavy and (2) it did not produce sufficient heat to markedly speed up the mold drying. However, it was a step in the right direction.

The second torch produced was constructed of steel tubing with provision for introducing compressed air. This torch was both light in weight and capable of producing the desired temperatures for efficient drying.

Characteristics of the operation of the torch are as follows: Air pressure is 90 to 105 psi., while the gas pressure varies from 15 to 20 psi. The torch is lighted and the air adjusted to produce a flame with a blue base and a yellow tip. Care must be taken in the first use of these torches to prevent burning of the molds. They develop temperatures in excess of 2600° F. The commonly used type of torch is the single-unit torch, using a single cylinder of propane gas.

Four-Unit Torch

However, the larger plants producing larger molds with expansive surfaces exposed for drying have gone to the four-unit type of torch,

Skin drying a mold with four-unit propane-gas torches.
(Courtesy, Sumner Iron Works, Everett, Wash.)

backed up with large storage tanks above ground or banks of manifolded single 200-lb. tanks of the propane gas. In this particular foundry, the gas is piped from two banks of two cylinders each to three stations dispersed throughout the foundry to serve all of the large molding floor. Pressure regulation is handled by a single-stage regulator to keep a constant pressure of 15 to 20 lb., and flexibility of the torch is obtained by the use of a 50-ft. length of ¼-in. propane-type hose at each station.

One of the most marked advantages resulting from the use of the propane torch is the reduction in the time necessary to produce the same depth of drying. The greater temperature developed by this torch, and the absence of any insulating material, such as soot, contribute to its faster drying action.

The surface of the mold seems to attain a greater hardness than when dried with the oil torch. This probably is a function of the higher temperature obtainable at the surface of the mold with the propane-type of torch.

Mold surfaces are left in a cleaner condition and with less foreign matter to disturb metal equilibriums which, in turn, have a bearing on the casting surfaces obtained.

The propane torch also seems to dry pockets and undercuts in molds to a greater extent than was heretofore possible.

Although no actual cost figures are available, it is believed that the propane torch is no more costly to operate than are other methods of drying, and that it does produce a saving in the labor involved in its operation.

Based on the foregoing reasons, the propane-type of torch for the skin drying of molds has been adopted in the author's foundry and in other foundries in the Northwest.

FOUNDRY SAND

Research Committee Forms New Plans

THE Foundry Sand Research Committees met at the Statler Hotel, Cleveland, December 6, 7 and 8, for the purpose of discussing progress in sand research, to plan future work, and to select papers for the 50th Anniversary Convention to be held in Cleveland May 6-10, 1946.

One of the significant achievements of the meetings was the restatement of the objectives and field of work of each committee. This is expected to minimize duplication of work.

In connection with the properties of sands at elevated temperatures, D. C. Williams, A.F.A. Sand Research Fellow, Cornell University, Ithaca, N. Y., presented a 30-minute color movie showing the behavior of 8 sand mixtures at 2500° F. There was unanimous approval of the work and considerable discussion regarding possibilities of this method of studying sand characteristics.

The Light Metals Committee was disbanded as being superfluous but there will be representation of light metals foundrymen on other committees. The Committee on Physical Properties of Non-Ferrous Sands At Elevated Temperatures will continue its activities. Re-organization of the Core Test Committee is expected to facilitate study in the broad field of cores and core practice.

The Committees on Flowability and Deformation discussed methods of testing and will study relationships between the two properties. Green sand properties were discussed at considerable length by a committee which has been enlarged to carry on extensive work on ramming methods and effect of mulling.

The inadequacies of some of the present methods of grading were considered in a meeting of the Grading and Fineness Committee, in which the advantages of the cumulative curve over the A.F.A. Fineness Number were emphasized. Feeling that its present work had been completed, the Sintering Test Committee changed its name to Mold Surface Committee and formulated plans for studying reactions at the mold-metal interface.

There was unanimous agreement at the Executive Committee Meeting that a rigid rule should be adopted requiring all committee members to attend meetings, send a qualified proxy, or have a good excuse for failure to attend. Failure to attend meetings, or to answer or acknowledge correspondence promptly, will be considered cause for dropping committee members. The committee passed a motion to adopt the cumulative curve for expressing fineness and recommended that is should be published as a tentative standard.

(Photo courtesy Bradley Booth, Carpenter Bros. Inc.)

Foundry Sand Research Project, Executive Committee, met at Hotel Statler, Cleveland, December 8, to establish future plans and ideas in connection with the project.

Southern Pipe Company Opens Research Service

AMERICAN Cast Iron Pipe Co., Birmingham, Ala., prompted by the desire to render a public service, is making available its extensive test and research facilities to industry, schools or individuals. It is not the intention of the company to enter into competition with existing commercial testing laboratories. Such testing and research work as is undertaken will be done on the basis of rendering an unusual service.

A booklet explaining this service has been published by American Cast Iron Pipe Co.

Effect of Table Rise (Strain Rate) on Hot Strength of Bentonite Bonded Sands

By H. W. Dietert, President,
Harry W. Dietert Co., Detroit

• Reproducibility of hot strength tests of foundry molding materials, which may develop different characteristics at various points of the test temperature range, may be secured by selection of a predetermined strain rate value.

HOT strength tests on foundry molding materials are conducted under a very wide temperature range, for example, from 500 to 2500° F. Within this temperature range, the test specimen of the material under test may be a hard brittle substance at the lower temperature and a very plastic material at the higher temperature.

The problem presents itself immediately whether a constant rate of load (stress), or a constant rate of table rise (strain), should be used during the application of the load. The author believes that a constant rate of loading (stress) which would be applicable for both the very brittle and plastic materials is impracticable.

Nearly all hot strength tests made to date have been made under conditions of constant rate of table rise (strain). The rate of table rise (strain) should be selected at a predetermined value; for example, 1-in. per min. when reproducible test results are desired.

Test Conditions

It is plausible that, at some value of table rise (strain) the maximum number of desirable test conditions would be obtained. To obtain a partial answer to this important problem, hot strength tests were made under varying table rise.

Green sand specimens of the 1⅛x 2-in. size were used, consisting of a sand composed of No. 17 washed and dried sand bonded with 5 per cent western bentonite and tempered with 2.5 per cent moisture. The sand was prepared in an 18-in. diameter laboratory muller, screened through No. 6 mesh sieve after mixing and sealed in an air-tight container, allowing 30 min. tempering time before using the material.

Hot strength determinations were made at temperatures of 500, 1000, 1500, 2000 and 2500° F. in a 1940 model dilatometer equipped with a 2-in. I.D. furnace and an adjustable volume hydraulic pump with motor drive.

The green sand specimens were allowed to soak for a period of 12 min. before applying the load. The current input into the furnace was such as to obtain a furnace temperature recovery in 2 min.

Table 1 shows hot strength in psi. as obtained for table rise (rate of strain) from 0.5 to 1.25 in. per min. All test readings were recorded and only two readings in this group of tests were rejected. Good reproducibility was obtained at all rates of table rise. A graphical presentation of this data is shown in Fig. 1.

In general, there is an increase in hot strength as the table rise (strain) is increased from 0.5 to 1.25 in. per min. with the exception of the hot strength for the 2500° F. range. For table rise from 0.5 to 0.75 in. per min., there is a marked increase in hot strength for temperatures to 500, 1000, 1500 and 2000° F.

From this data, a table rise from

Table 1

THE EFFECT OF TABLE RISE (STRAIN RATE) ON HOT STRENGTH (PSI.) OF BENTONITE BONDED SANDS

	Hot Strength (psi.) at Temperatures				
	500° F.	*1000° F.*	*1500° F.*	*2000° F.*	*2500° F.*
	Rate of Table Rise—0.5 in. per min.				
	94*	100*	496	80	4
	70	80	437	80	4
	68	86	420	76	4½
	78	76	446	....	4
		86	454	....	.....
Avg.	72	82	450	79	4
	Rate of Table Rise—0.75 in. per min.				
			493	98	
	100	87	527	90	4½
	90	94	462	104	4½
	88	83	532	103	4½
				90	.....
Avg.	93	88	503	97	4½
	Rate of Table Rise—1.0 in. per min.				
	83		482	105	
	100	90	524	100	4+
	87	94	477	111	5
		96	512	105	5
Avg.	90	93	499	105	5
	Rate of Table Rise—1.25 in. per min.				
	112	103	512	115	4
	96	110	520	110	4
	96	110	510	103	4
	96	108	532		3
Avg.	100	105	518	109	4

*Readings rejected.

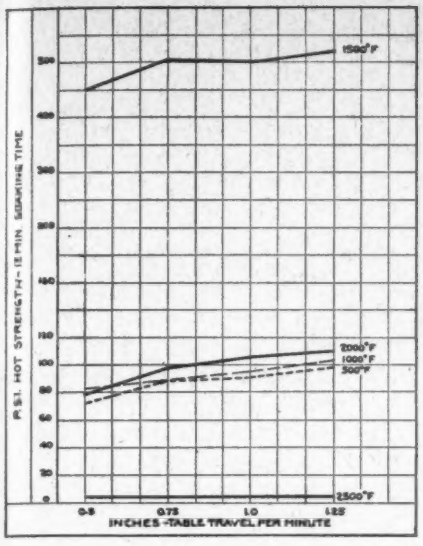


Fig. 1—Hot strength of green sand specimens plotted against table rise.

0.75 to 1.0 in. per min. under no load should be chosen to obtain a table rise rate (strain rate) which produces the least effect on hot strength readings.

For tests where data is interchanged among certain investigators, a table rise of 1.0 in. has been chosen and seems to meet conditions such as:

1. Not too time consuming.
2. Not too rapid to make it difficult to take psi. readings.
3. Suitable for hot deformation readings.
4. Adaptable to both brittle and plastic materials.
5. Suitable to obtain reproducible hot strength readings.

The data presented herein is only the beginning, and much additional work must be done to obtain complete information before further standardization on the rate of table rise may be accomplished.

In a letter received by the Association, one foundry executive has this to say about apprentice training: "The training of apprentices is not a charitable or philanthropic activity. It is purely an investment in life insurance, and the life covered, is that of our industry. To neglect apprentice training, is to stop putting fuel into the firebox, or, in language that is more familiar to us—'cheat on our coke charges.'"

MELTING MAGNESIUM ALLOYS

(Continued from Page 62)

to be even damp. This means that flux drums should be kept covered.

Much work has been done on methods of gas removal and on a more positive method of grain refinement.

A number of materials, such as some of the alkaline earths and some of the carbides and graphite, do give results when added to the melt, but so far none of them has proved to give consistent results.

Great promise has been found in chlorine gas bubbled through carbon tetrachloride and then passed through the melt. This process, when done in a silicon-carbide crucible, has proved its ability to clean, degas and give grain refinement all in one operation. However, at the present time not much is known about this process and, as both chlorine and carbon tetrachloride are toxic and corrosive chemicals, their handling by the average person is somewhat dangerous unless proper precautions are observed. The present practice gives good results and should be followed until the chlorine-carbon tetrachloride method has been thoroughly studied.

Conclusion

In closing, it would be well to mention two points on safe handling. All crucibles should be gone over between heats with a ball peen hammer to make sure that there are no thin spots or cracked welds. A small leak of magnesium into the furnace produces such an intense heat that it will burn the whole bottom out of the crucible, resulting in a hazardous magnesium fire. Also, all furnaces should be kept clean, as the iron scale from the crucibles produces a thermite reaction with magnesium when hot and can cause a violent and explosive reaction.

Observance of these basic melting practices will pay dividends in better castings.

Defect Committee Picks Title for Publication

AT a meeting of the Committee on Analysis of Casting Defects, held at the National office recently, it was decided that the title of the book to be published by this committee will be titled "Outline of the Causes of Gray Iron Casting Defects."

The Editorial Committee is working diligently to prepare the assembled material for publication to make this book a "must" for every foundryman's library.

A painting by Frederick B. Taylor, Montreal, Canada, illustrating the pouring of gun parts in a brass foundry of a Canadian war plant.

NATIONAL EDUCATIONAL PROGRAM

Outlines Objectives

THE casting industry faces an acute problem.

Foundries are unable to supply sufficient castings to meet the reconversion needs of manufacturers. The competitive position of the casting process may suffer as the result of failure to maintain quality standards set during the recent war. By attracting adequately trained men to the foundries, the current and the future aspects of the problem both can be solved.

The solution to the task of procuring and training foundry workers is an educational and publicity program which properly presents opportunities afforded by the foundry industry, breaks down the antipathy of the public to foundries, and advertises the universal importance of castings.

TDP Sponsors Educational Program

The American Foundrymen's Association has long had committees active in the field of personnel training and other educational activities. Recently the work was correlated under the National Educational Program which is a function of the Technical Development Program. The National Educational Program, broad in scope and of a continuing character, has been unanimously approved by the Board of Directors. An outline of the program, which will be discussed in considerable detail in succeeding issues of AMERICAN FOUNDRYMAN, is shown on page 81.

Educational institutions, item I in the outline, offer the greatest opportunity to contact prospective foundry workers during their formative years. This involves youth encouragement, which has been ably discussed by A.F.A. President Fred J. Walls, International Nickel Co., Detroit, before a number of chapters. Starting in grade school, interest can be developed in castings, and the industry that makes them, through booklets, movies, and trips to local foundries. Academic high schools can receive the same treatment in a more advanced form. Technical and vocational high schools should receive similar aid, but, in addition, should have the cooperation of A.F.A. chapters in securing equipment, supplies, special speakers, and summer foundry jobs for students and teachers. In general, engineering schools, which furnish most of the designers, metallurgists, and research workers, need encouragement and assistance in improving the quality of their foundry instruction.

Cooperation with vocational schools and engineering schools has been carried on through A.F.A. national committees. The Apprentice Training Committee has aided in establishing standards for four-year apprentice training courses, and annually sponsors national apprentice contests in molding and pattern making. The Northeastern Ohio chapter has done well in cultivating local school authorities and student advisors, and has worked closely with the Cleveland Trade School. Outstanding is the Milwaukee Vocational School in which the Wisconsin chapter is constantly interested. The engineering school committees have a well developed program for improving foundry instruction, promoting research, and encouraging technically trained men to enter the casting industry.

Industry Requires Attention

The foundry industry itself requires attention. Education of the public is not sufficient; management must develop pride in industry. Negligent in some cases, management must rectify undesirable conditions which exist in some foundries. Foundries must keep abreast or ahead of other metal fabricators in establishing new policies and improved conditions conducive to getting and holding workers.

The technical press publishes technical and scientific facts related to manufacturing processes. It is necessary to furnish foundry information to publishers as it becomes available, and to get them to correct erroneous statements which appear in print.

Newspapers can be a means of creating favorable interest in the foundry industry. Difficult to break into, the newspapers usually devote space only to stories and news of general concern. Continuous contact on the part of chapters and the national office staff will bring results.

A speakers bureau, managing foundrymen who can talk before the great variety of clubs, societies and organizations which exist, can do much to promote a friendly attitude toward the industry. Technical and professional groups, general interest groups, and youth organizations always are seeking speakers.

Lecture courses have been popular in a number of chapters and are of great value in interpreting latest foundry developments and promoting discussion of A.F.A. publications. Active in sponsoring lecture courses have been the Chicago, Detroit, Metropolitan, Southern California, Northern California and St. Louis chapters.

Exhibits Attract Attention

Exhibits, like lectures before general interest groups, attract a surprising amount of attention. Castings normally achieve little recognition from laymen who unknowingly use them every day. Exhibited as a unit by itself, unobscured by other components of a machine, free of surface finishes, a casting becomes as interesting as the complex structure of which it may be the most important part. The Chicago chapter has sponsored a full size small modern operating foundry at the Museum of Science and Industry. The Twin City chapter has several exhibits of interesting castings which are moved about among schools, libraries, county fairs and the University of Minnesota, Minneapolis. Also scheduled for exhibition by several chapters are the 1944 Apprentice Patternmaking Contest patterns.

Since 1943, when the first Foundation Lecture was given, authoritative discussions of various problems of the casting industry have been presented at the Annual Meeting by leaders in the field. Reprinted

and distributed widely, the Foundation Lectures have done much to direct the thoughts of technical men outside the foundry industry toward the problems of casting production.

It is evident that the National Educational Program is intended to be comprehensive. It will cover all phases of education and publicity, outside and within the casting industry, from school youth through foundry management. It will be a continuous program, to be executed over a long period of time.

Although some of the work clearly is the responsibility of the National Office and of National Committees, much of the work is expected to be done by the chapters. Local conditions will not allow the work to be carried on in the same way, nor will the same degree of success be achieved, by all chapters. However, some part of the program can be conducted in every chapter locality. Many chapters have promoted some of the educational work, successfully and with gratifying results, which is shown in the outline.

Chapter Educational Committees are particularly effective because they invariably contain foundrymen prominent in municipal affairs, known to school authorities, and to the general public.

The ultimate objective of the National Educational Program of A.F.A. is to attract adequately-trained personnel to the foundry industry. This is expected to be accomplished by encouraging and aiding schools to offer vocational, technical, and scientific training necessary to provide a continuous supply of all types of foundry workers; by convincing young men that opportunities for learning on the job are good, and that the possibilities for advancement in the foundry industry are boundless; by demonstrating and advertising that the foundry is a good place to work.

The following outline shows the essentials of the National Educational Program which is carried on as part of the Technical Development Program. Whether the work can be done better by A.F.A. chapters or by the staff of the Technical Development Program is indicated. Future articles will describe in detail the various phases of the program, and explain its progress.

I Educational Institutions

Grade Schools

Type of Training Offered: None.

Type Teachers Desired: No special.

Primary Responsibility: National Office.

Type of Aid Suggested: General Propaganda (simple). Booklets on historical and romantic side glamourizing industry, include applications known to children of this age and in which they are interested; might even be a series of booklets. Speakers on industry with movie.

Results: More interest among younger students in foundry as profession or trade.

High Schools (Technical)

Type Training Offered: Pre-apprentice type training (Smith-Hughes Act) or manual training course.

Type Teachers Desired: Ex-journeymen with foundry background.

Primary Responsibility: Local Chapter.

Type Aid Suggested

1. Visual aids in teaching—movies of individual operations as well as general production (no advertising).
2. Equipment and supplies, including patterns.
3. Books and pamphlets of simple trade and technical nature.
4. Talks of general nature by prominent foundrymen on opportunities.
5. Plant inspection trips.

Methods of Chapter Cooperation

1. Sponsor organization for interested students.
2. Speakers for student organization.
3. Invite all instructors to chapter meetings.
4. Cultivate student advisors.
5. Cultivate local school authorities.
6. Hold local competitions such as essay and molding, patternmaking competitions with worthwhile monetary prizes.
7. Follow state laws to take advantage of them.
8. Placement bureau for graduates.
9. Employment of both teachers and students during vacation periods.
10. Invite students to chapter meetings.
11. Provision for a "Students Night" by chapter.

National Cooperation

1. Supply visual aids.
2. Supply books and pamphlets on foundry operations and opportunities.
3. Sponsor summer school for teachers on the industry.

Results

1. Pre-apprenticeship students.
2. Semi-skilled workers with foundry background.

High Schools (Academic)

Type Training Offered: None or manual.

Type Teachers Desired: None or special depending on curricula.

Primary Responsibility: Local Chapter.

Type Aid Suggested: Propaganda and information type.

1. Booklets on the foundry as a career showing various jobs and opportunities.
2. Speakers at special lectures for students.
3. Movies of general application of foundry products.

Methods of Cooperation

1. Supply speakers for student body sessions.
2. Cultivate local school authorities.
3. Cultivate student advisors and teachers in courses similar to "Occupations."

National Cooperation

1. Supply booklets.
2. Supply movies.

Results

1. Interest in industry among those who will seek higher education.
2. Possible source of semi-skilled help.

Trade and Vocational Schools

Type of Training Offered: Apprentice and/or related instruction to apprentices.

Type of Teachers Desired: Trained journeyman with

broad knowledge of trade taught and enthusiasm.

Primary Responsibility: Local Chapter.

Type Aid Suggested

1. Visual aids for various operations.
2. Recommended courses.
3. Equipment and supplies, including patterns.
4. Books and pamphlets of use in teaching various trades.
5. Talks by foundrymen to classes on specific subjects at level of student understanding.
6. Plant inspection trips.

Methods of Chapter Cooperation.

1. Sponsor organization for interested students.
2. Speakers for student organization.
3. Invite all instructors to chapter meetings.
4. Cultivate student advisors.
5. Cultivate local school authorities.
6. Hold local competitions such as essay and molding, patternmaking competitions with worthwhile monetary prizes.
7. Follow state laws to take advantage of them.
8. Placement bureau for graduates.
9. Employment of both teachers and students during vacation periods.
10. Invite students to chapter meetings.
11. Provision for an "Apprentice Night" by chapter.
12. Texts for related work applying principles to practice.

National Cooperation

1. Supply visual aids.
2. Supply books and pamphlets.
3. Organize summer course for instructors.

Results

1. Skilled workmen and material for minor supervisory forces.

Universities (Engineering Schools)

Type of Training: Engineering.

Type of Teachers Desired: Engineering education with foundry background.

Primary Responsibility: National Office.

Secondary Responsibility: Local Chapters.

Type Aid Suggested

1. Recommend course of instruction, including course outlines, costs, physical properties, processes, uses, photographs (blow ups).
2. Assist in securing equipment and materials.
3. Supply visual aids for instructors, such as movies, slides on equipment and practices, models, product and process exhibits.
4. Make available samples of good and bad practice and design.
5. Supply teachers and students with good technical literature from engineering standpoint.
6. Sponsor an up-to-date text book.
7. Supply lectures to students and faculties on possibilities and applications of castings.
8. Sponsor employment of both faculty and students during summer months.
9. Supply speakers to student engineering groups.
10. Suggest to chapters that they hold meetings for local engineering school faculty with speakers who are experts.
11. Supply information to instructors on machine design, metallurgy, strength of materials.
12. Get proper information on cast materials into text books.
13. Sponsor basic research.
14. Sponsor competitive student projects such as essay contests.
15. Supply list of subjects for theses.
16. Sponsor contests for post-graduate work to men in industry with prizes to cover expenses of work.
17. Establish undergraduate scholarships.
18. Subsidize summer course for engineering instructors to discuss subjects such as design on technical level.
19. Publish articles and papers for distribution to students.
20. Encourage faculty members to do consulting work for foundries.
21. Exchange of personnel between faculty and industry.
22. Sponsor evening courses of advanced study.
23. Issue monthly or quarterly bulletins to students.
24. Promote regional meetings at universities.

Methods of Cooperation

1. National
   a. Suggest outline of proper course designed to coordinate with engineering curricula.
      (1) Supply course outlines.
      (2) Supply specific information on relative costs, physical and mechanical properties, processes, applications, etc.
      (3) Supply visual aids such as motion pictures, slides, models, product and process diagrams and exhibits.
      (4) Books and pamphlets on specific subjects as desired.
   b. Supply up-to-date text books.
   c. Supply lecturers to students and faculties on possibilities and applications of castings. (Seminars)
   d. Assist schools in securing necessary equipment and supplies for proper course.
   e. Supply information to the instructors in related fields such as machine design, strength of materials, mechanics, metallurgy.
   f. Sponsor basic research.
   g. Sponsor competitive student projects such as essay contests with substantial monetary prizes.
   h. Compile and supply lists of subjects for theses.
   i. Sponsor post-graduate research among men of the industry through competitive examinations for expenses during period.
   j. Establish undergraduate scholarships through competitive examinations.
   k. Subsidize summer course for engineering instructors to discuss such subjects as design and properties on technical level.
   l. Publish technical articles and papers to students.
   m. Encourage exchange of faculty and men of industry on yearly basis—industry men to teach and study for advanced degrees or take advanced work.

n. Sponsor summer employment of faculty and students.
o. Issue monthly or quarterly bulletin to students in engineering schools.
p. Encourage leading technical men to participate in Society for Promotion of Engineering Education.

2. Chapter
   a. Hold regional meetings with local engineering schools.
   b. Sponsor evening courses in advanced foundry subjects in connection with local engineering schools.
   c. Hold meetings for local engineering school faculty to be addressed by experts in a specific field.
   d. Notify local faculty members of meetings in which they may be interested, such as design and physical properties, etc.
   e. Sponsor short courses in modern cast materials at universities.
   f. Work for employment of faculty and students in summer months.
   g. Supply speakers to local student engineering groups.

Results
1. Focus more attention on foundry products.
2. Give engineers a better understanding of design and application of castings.
3. Stimulate interest of engineering schools in the castings industry.
4. Eventually more engineers entering industry.
5. Eventually raise level of industry.
6. More prospects for executive vacancies in industry.
7. Quicker solution of the industry's vexing technical and management problems.

II Foundry Industry

A. To acquaint foundrymen with their industry, to encourage management to adopt better methods and to encourage self-improvement of foundry and related workers.

B. Functions of T.D.P. Staff
1. Management
   a. Supply with pamphlet on good foundry housekeeping, employer-employee relationships, treatment of new employees, making reference to literature where additional details are available.
   b. Supply with pamphlet on value of graduate engineers to foundry, how to secure them and treat them—correlate with Committee for Cooperation with Engineering Schools.
   c. Supply with pamphlet on history of industry, job outlook, types of work, and future of industry. To be given to old and especially to new employees.

C. Functions of local chapter
1. Journeymen, foremen, supervisors and technical staff
   a. Chapter lecture course.
   b. In-plant training.
   c. Night classes or technical institute.

III Technical Press

A. To advertise the foundry industry through technical literature not published by A.F.A. and to guard against misrepresentation of facts about the industry and its products.

B. Functions of T.D.P. Staff
1. Handbook Editors
   a. Supply with CAST METALS HANDBOOK.
   b. Check other handbooks to see that they contain proper information about castings.
   c. Write sections on castings and the foundry industry.
2. Technical Books
   a. Write chapters and sections of books on topics related to foundry practice.
3. Technical Periodicals
   a. Write or secure articles for technical periodicals and trade papers.
4. Advertisements
   a. Call attention of ad-writers, agencies, sponsoring company to misrepresentations regarding castings.

IV Newspapers

A. To supply news releases, pictures, cuts, etc., of meetings, personal appearances, talks, achievements, of foundrymen and to publicize foundry developments of general interest.

B. Function of T.D.P. Staff and local chapters
1. Trade journals.
2. Technical journals.
3. Industrial newspapers.
4. Local newspapers.

C. Functions of local chapter
1. Columnists
   a. Report oddities and human interest items.
   b. Arrange trip through modern foundry.
2. Feature writers
   a. Arrange trip through modern foundry.
   b. Encourage story-writing about local interest items such as the largest, smallest, or most important casting made locally.
   c. Story contrasting new labor-saving devices, etc., with old back-breaking methods.
   d. Play up any "character" on the crew, or someone with an unusual hobby.
3. Rotogravure
   a. One or two page spread of foundry operations emphasizing cleanliness, good lighting, labor-saving devices, sanitary facilities, safety, payment of bonuses, holiday party, etc.

V Speakers Bureau

A. To advertise and supply speakers from among A.F.A. members, movies, slides, etc., to the general public.

B. Speakers and local publicity to be responsibility of local chapters, some material and the national publicity to be supplied by the T.D.P. Staff.
1. Engineering societies, such as ASM, AWS, SAE, ASME, AIEE, etc.
   a. Stress design, special properties and special applications, weldability, etc.

(Concluded on Page 85)

NEW ASSOCIATION MEMBERS

(November 15 to December 15, 1945)

• Twenty-nine Chapter Membership Committees "rang the bell" during the November 15-December 15 period to bring 172 new members into A.F.A. activities. This includes 9 members added to the Mexico City chapter and 17 to the "baby" chapter—Central Illinois. However, Northeastern Ohio and Philadelphia were not outdone as they added 17 new names to their rosters. Chicago with 13 and Eastern Canada and Newfoundland and Western Michigan with 11 also showed a sharp increase in membership.

Conversion—Personal to Company

***Lester B. Knight & Associates, Chicago (L. B. Knight, Owner).**

BIRMINGHAM CHAPTER

Sam Barnett, Coremaker, Stockham Pipe Fittings Co., Birmingham, Ala.
Herbert T. Lavender, Jr., American Cast Iron Pipe Co., Birmingham, Ala.

CANTON DISTRICT CHAPTER

Albert F. K. Chen, Met. Engr., Timken Roller Bearing Co., Canton, Ohio.
John L. Kickerson, Prod. Engr., The Pitcairn Co., Barberton, Ohio.
Theo. C. McFall, Spec. Engr., American Steel Foundries, Alliance, Ohio.
W. N. Mullane, Div. Ind'l. Engr., Republic Steel Corp., Newton Falls, Ohio.
Laurence J. Venne, Spec. Engr., American Steel Foundries, Alliance, Ohio.

CENTRAL ILLINOIS CHAPTER

Oscar Albaugh, Annealing Fore., Peoria Malleable Castings Co., Peoria, Ill.
Charles Bavis, Melt. Fore., Peoria Malleable Castings Co., Peoria, Ill.
John Benko, Fdry. Fore., Peoria Malleable Castings Co., Peoria, Ill.
Chester Berg, Insp. Fore., Peoria Malleable Castings Co., Peoria, Ill.
B. W. Branson, Pur. Agent, Peoria Malleable Castings Co., Peoria, Ill.
Ray Bruwaene, Molder, Pekin Foundry & Mfg. Co., Pekin, Ill.
W. Frank Burk, Paymaster, Peoria Malleable Castings Co., Peoria, Ill.
Tom Dougherty, Fdry. Fore., Peoria Malleable Castings Co., Peoria, Ill.
Mason W. Haigh, Engr., Cleveland Tramrail Div., Wickcliffe, Ohio.
Robert L. Haigh, Engr., Cleveland Tramrail Div., Wickcliffe, Ohio.
Jess Oldham, Timestudy, Peoria Malleable Castings Co., Peoria, Ill.
W. Scott Roby, Treas., Peoria Malleable Castings Co., Peoria, Ill.
Emil Schmidt, Patt. Fore., Peoria Malleable Castings Co., Peoria, Ill.
Carl R. Steinke, Acct., Pekin Foundry & Mfg. Co., Pekin, Ill.
Howard Stewart, Ship. Fore., Peoria Malleable Castings Co., Peoria, Ill.
Harry G. Stroot, Fdry. Fore., Peoria Malleable Castings Co., Peoria, Ill.
George Woodruff, Labor Fore., Peoria Malleable Castings Co., Peoria, Ill.

CENTRAL INDIANA CHAPTER

Joseph C. Metelko, Asst. Fore., International Harvester Co., Indianapolis.

CENTRAL NEW YORK CHAPTER

Andrew Boglionne, Cayuga Cordage Mfg. Co. Inc., Auburn, N. Y.
Kenneth E. Penny, Pres., Cayuga Cordage Mfg. Co. Inc., Auburn, N. Y.
Albert B. Sherwood, Mgr., Cayuga Cordage Mfg. Co. Inc., Auburn, N. Y.
James Smith, Gen. Mgr., Cayuga Cordage Mfg. Co. Inc., Auburn, N. Y.
Robert A. Whitwood, Field Engr., Electro Refractories & Alloys Corp., Buffalo, N. Y.

CENTRAL OHIO CHAPTER

Thos. C. Alford, Fdry. Tech., Lennox Furnace Co., Columbus, Ohio.
Cecil A. Powell, National Supply Co., Springfield, Ohio.

CHESAPEAKE CHAPTER

William T. Watson, Vice Pres., The Caroline Foundry Co., Baltimore, Md.

CHICAGO CHAPTER

Henry Bernhard, Foreman, Hills-McCanna Co., Chicago.
Edward Geoffrey, Fore., Howard Foundry Co., Chicago.
Stephen F. Kempa, Fore., Hills-McCanna Co., Chicago.
Emmett C. Lewis, Chief Insp., Howard Foundry Co., Chicago.
Charles F. Maxwell, Jr., Met., Howard Foundry Co., Chicago.
Russell McKamen, The Western Foundry Co., Chicago.
Trygre Fredrik Myhren, Met., Apex Smelting Co., Chicago.
Otto H. Rosentreter, Asst. Sales Mgr., National Engineering Co., Chicago.
Frank Joseph Sabla, Whiting Corp., Harvey, Ill.
Harold H. Siegel, Met., Howard Foundry Co., Chicago.
Charles G. Wieber, Supt., Sivyer Steel Cstg. Co., Chicago.
H. R. Youngkrantz, Met., Apex Smelting Co., Chicago.
Frank Zuchel, Insp., Howard Foundry Co., Chicago.

CINCINNATI DISTRICT CHAPTER

Louis J. Homan, Owner, Louis J. Homan Metals, Cincinnati.
John G. Joerg, Patt. Shop Fore., Haven Malleable Cstgs. Co., Cincinnati.
Walter H. Placke, Sales Mgr., Dayton Castings Co., Dayton, Ohio.
Fred Schnenkner, Gen. Fore., Haven Malleable Castings Co., Cincinnati.

DETROIT CHAPTER

G. R. Bryant, Sales Engr., American Foundry Equipment Co., Detroit.
Lester Godre, Melter, Michigan Malleable Iron Co., Detroit.
Manford E. Mason, Tool Engr., Cadillac Motor Car Co., Detroit.

SAGINAW VALLEY CHAPTER

Edmund Gilliam, Per. Dir., Eaton Mfg. Co., Vassar, Mich.
William O. Melvin, Pur. Agent, Eaton Mfg. Co., Vassar, Mich.

EASTERN CANADA & NEWFOUNDLAND CHAPTER

Victor A. Blais, Fdry. Fore., Crane Ltd., Montreal, Que.
Gerard Dumontier, Inst., Shawinigan Technical Institute, Shawinigan Falls, Que.
J. W. Eller, Cons. Chemist, Milton Hersey Co. Ltd., Montreal, Que.
George R. Ewan, Prod. Engr., Dominion Engineering Works Ltd., Lachine, Que.
T. Gordon, Canadian Car & Foundry Ltd., Montreal, Que.
Claude Jeannotte, Fdry. Clerk, Warden King Ltd., Montreal, Que.
Henry D. S. Jones, Sales Mgr., Lynn MacLeod Metallurgy, Ltd., Thetford Mines, Que.
Frank Machnik, Dominion Engineering Works Ltd., Lachine, Que.
Alex Saunders, Dominion Engineering Works Ltd., Lachine, Que.
J. Simpson, Canadian Car & Foundry Ltd., Montreal, Que.
Maurice J. Villeneuve, Verdun, Que.

METROPOLITAN CHAPTER

Auguste Bohler, Mgr. Treas., Amerlux Steel Products Corp., New York.
Harold E. Bourassa, Met., Reynolds Metals Co., Springfield, Mass.
A. Paul DeVita, Sales Engr., Robins Conveyors Inc., Passaic, N. J.
Four Continent Book, New York.
Richard B. Kropp, International Nickel Co., New York.
C. D. Preusch, Met., Crucible Steel Co. of America, Harrison, N. J.
F. J. Sedlock, Foreman, Perfect Doll Moulds Inc., New York.
F. M. Stearn, Dev. Engr., Titarium Alloy Mfg. Co., Niagara Falls, N. Y.

MEXICO CITY CHAPTER

***Fundicion Y Tallares America, S.A. Mexico, D.F. (Ernesto Macias Sauza, Gerente).**
***Fundidores Nacionales, Monterrey, N.L. Mexico. (Raul Morales, Manager).**
***Industrial de San Bartolo, S.A. de C.V., Naucalpan, Mexico. (Agustin Quintanilla y Ducland, Pres.).**
Pedro Quintanilla Duclaud, Industrial de San Bartolo, S.A. de C. V., Naucalpan, Mexico.
Carlos Quintanilla Rivero, Industrial de San Bartolo, S.A. de C.V., Naucalpan, Mexico.
Otto F. Jagielski, Cia. Constructora Maquinaria, Atzcapotzalco, D.F. Mexico.
***Maquinaria y Equipo, Ferrocarril, Mexico, D.F. (J. G. Pulido, Supt.).**
Alberto Phillips Skinfield, Mgr. of Hierro y Acero de Mexico, Mexico D.F.
Carl-Gustaf Syren, Fdry. Mgr., A.B. Nordiska Armatur Fabrikerna, Linkoping, Mexico.

MICHIANA CHAPTER

Kennth Biltz, Dodge Mfg. Corp., Mishawaka, Ind.
H. L. Enyert, Mold. Fore., Sibley Machine & Foundry Corp., South Bend, Ind.
Richard Lange, Mold. Fore., Sibley Machine & Foundry Corp., South Bend, Ind.
Kenneth Matz, Mold. Fore., Sibley Machine & Foundry Corp., South Bend, Ind.
F. T. McGuire, Met., Sibley Machine & Foundry Corp., South Bend, Ind.

NORTHEASTERN OHIO CHAPTER

Earl V. Baker, Fore., The Ferro Machine & Foundry Co., Cleveland.
Noah L. Butkin, Sales Engr., H. Kramer & Co., Chicago.
Robert W. Dally, Sales Repr., Harbison-Walker Refractories Co., Cleveland.
John Gaino, Pattnmkr., The Royal Pattern Works, Cleveland.
Owen J. Gartner, Sales Mgr., Steelblast Abrasives Co., Cleveland.
Albert Sydney Johnson, Met., The Lake City Malleable Co., Cleveland.
Frank Kmiotek, Supv., The Ferro Machine & Foundry Co., Cleveland.
C. T. Locke, Asst. Supt., The Ferro Machine & Foundry Co., Cleveland.
Michael S. Lomaka, Draftsman, The Ferro Machine & Foundry Co., Cleveland.
John C. Lopatta, Supt., The Falcon Bronze Co., Youngstown, Ohio.
Rex J. Myers, Equipt. Engr., The Ferro Machine & Foundry Co., Cleveland.
Vincent Schaaf, Fdry. Supt., Pittsburgh, Pa.
Sydney Simmons, Fdry. Supt., The Lake City Malleable Co., Cleveland.
Milton R. Vipond, Sales Engr., Aluminum Co. of America, Cleveland.
T. C. Watts, Asst. Gen. Mgr., The Falcon Bronze Co., Youngstown, Ohio.
Warner A. Wick, Gen. Mgr., Chg. of Prod., Falcon Bronze Co., Youngstown, Ohio.
William Zabkar, Mold. Foreman, The Lake City Malleable Co., Cleveland.

N. ILLINOIS-S. WISCONSIN CHAPTER

Roy E. Norberg, Prod. Mgr. of Sleeves, Gunite Foundries Corp., Rockford, Ill.
Robert M. Ruth, Lab. Techn., Fairbanks Morse & Co., Beloit, Wis.
F. W. Thayer, Gunite Foundries Corp., Rockford, Ill.

NORTHERN CALIFORNIA CHAPTER

Earl E. Greenwell, Pattnmkr., Mare Island, Vallejo, Calif.
Clifford J. Hooper, Owner, C. J. Hooper Pattern Works, San Francisco.

NORTHWESTERN PENNSYLVANIA CHAPTER

***Erie Bronze Co., Erie, Pa. (J. H. Piper, Met.).**
Seth Hanna, Asst. Fore., Chicago Pneumatic Tool Co., Franklin Pa.
Stephen R. Stroup, Sales, Peerless Mineral Products, Conneaut, Ohio.

*Company Members.

ONTARIO CHAPTER

J. A. Koeppe, Jr., Dominion Foundries & Steel, Hamilton, Ont., Canada.
J. B. Medley, Supt., A. H. Tallman Bronze Co. Ltd., Hamilton, Ont., Canada.
John Reith, Canada Metal Co., Toronto, Ont., Canada.
V. R. Wagner, Foundry Supt., Kondu Mfg. Co. Ltd., Preston, Ont., Canada.

OREGON CHAPTER

Birger Arnborn, Fdry. Inst., Benson Polytechnic School, Portland, Ore.
Saraca Clemente, Pacific Steel Foundry, Portland, Ore.
Otto Hansen, Coremaker, Vaughan Motor Co., Portland, Ore.
Lee E. Holcomb, Crawford & Doherty Foundry Co., Portland, Ore.

PHILADELPHIA CHAPTER

Edward J. Boyle, Met., The New Jersey Zinc Co., Palmerton, Pa.
Thomas S. Clay, Asst. Chemist, Ajax Metal Co., Philadelphia.
Harry M. Cox, Ajax Metal Co., Philadelphia.
Jan R. Dunsford, Jr., Ch. Mech. Engr., Pittsburgh Steel Foundry Corp., Glassport, Pa.
Ralph B. Fair, Engr., Abrasive Co., Philadelphia.
Allen S. Haines, Baldwin Locomotive Works, Eddystone, Pa.
John Long, Chemist, Ajax Metal Co., Philadelphia.
Charles R. McElwee, Jr., Asst. Chief Insp. Met., Bethlehem Steel Co., Bethlehem, Pa.
Vincent J. Murray, Ajax Metal Co., Philadelphia.
Francis H. Myers, Foreman, Ajax Metal Co., Philadelphia.
Ervin B. Owens, Ajax Metal Co., Philadelphia.
Herbert R. Palmer, Fore., Ajax Metal Co., Philadelphia.
Howard H. Peterman, Fore., Ajax Metal Co., Philadelphia.
David W. Shafer, Con. Met., Bethlehem Steel Co., Bethlehem, Pa.
Nicholas J. Skrip, Exp. Engr., Bethlehem Steel Co., Bethlehem, Pa.
Manus J. Walsh, Fore., Ajax Metal Co., Philadelphia.
Harold Williams, Supt. of Materials, Ajax Metal Co., Philadelphia.

QUAD CITY CHAPTER

J. L. Chapman, Partner, Chapman's Foundry, Augusta, Ill.
Boyd Hays, Gen. Fdry. Fore., Union Malleable Iron Co., E. Moline, Ill.
Vernon O. Johnson, Payroll Supv., Ordnance Steel Foundry Co., Bettendorf, Iowa.
Raymond A. Lindblom, Plant Aud., Ordnance Steel Foundry Co., Bettendorf, Iowa.
Lawrence Erwin Lynch, Yard Foreman, Ordnance Steel Foundry Co., Bettendorf, Iowa.
Chris. E. Oberlaender, Molding Sand Producer, Moline, Ill.
A. H. Peterson, Partner, Interstate Pattern & Machine Co., Rock Island, Ill.

*Company Members.

ST. LOUIS DISTRICT CHAPTER

Robert E. Hands, Met., Walworth Co., E. St. Louis, Ill.

SOUTHERN CALIFORNIA CHAPTER

Hilmar E. Binkele, Owner, General Pattern Shop, Los Angeles.
Wm. J. W. Erven, Fdry. Supt., Pacific Grey Iron Casting Co., South Gate, Calif.
Max J. Scharf, Met., D & M Machine Works, Torrance, Calif.
William B. Scott, Fdry. Supv., Commercial Enameling Co., Los Angeles.
Harry Vollstadt, Axelson Mfg. Co., Vernon, Calif.

TWIN CITY CHAPTER

J. C. Neemes, International Nickel Co., Minneapolis.

WESTERN MICHIGAN CHAPTER

Francis M. Cheever, Asst. Plant Mgr., Campbell, Wyant & Cannon Fdry. Co., Muskegon Hgts., Mich.
F. J. Clark, West Michigan Steel Foundry Co., Muskegon, Mich.
Frank Humestoon, Mech. Engr. Research, Clover Foundry Co., Muskegon, Mich.
C. N. Jacobson, Dake Engine Co., Grand Haven, Mich.
Paul A. Johnson, Jr., Dake Engine Co., Grand Haven, Mich.
*Moore Plow & Implement Co., Greenville, Mich., (Harold A. Vas, Pres.).
Ernest A. Nelson, Dept. Supt., Campbell, Wyant & Cannon Fdry. Co., Muskegon, Mich.
Irvie E. Rice, Personnel Director, Campbell, Wyant & Cannon Fdry. Co., Muskegon, Mich.
Herbert Schenck, Fdry. Supt., Moore Plow & Implement Co., Greenville, Mich.
Thomas J. Stone, Night Supt., Campbell, Wyant & Cannon Fdry. Co., Muskegon, Mich.
Bud Stonerock, Sec.-Treas., Moore Plow & Implement Co., Greenville, Mich.

WESTERN NEW YORK CHAPTER

Harold G. Liebel, Purch. Agent, Jewell Alloy & Malleable Co., Buffalo, N. Y.

WISCONSIN CHAPTER

Aldwin J. Beaulieu, Fore., Lakeside Malleable Castings Co., Racine, Wis.
R. W. Blankenheim, Partner, Badger Pattern Works, Milwaukee.
T. Harry Cochrane, Owner, T. H. Cochrane Laboratories, Milwaukee.
Ben Drewes, Fdry. Mgr., Zenith Foundry Co., West Allis, Wis.
Edward A. Grede, Est. Engr., Grede Foundries, Inc., Milwaukee.
Wm. S. Hansen, Williams & Hansen, Milwaukee.
William A. Mehner, Sales, Federal Fdry. Supply Co., Milwaukee.
Gilbert Schreck, Partner, Badger Pattern Works, Milwaukee.

OUTSIDE OF CHAPTER

Cohn A. Harrison, Penn State, State College, Pa.

National Educational Program

(Continued from Page 83)

2. Other Societies — Cost Accountants, Purchasing Agents, Sales Managers, etc.
   a. Talk on foundry cost system, standards for bidding on orders, inspection, casting in sales promotion.
3. Clubs—Kiwanis, Rotary, church groups, women's clubs and the like.
   a. Stress the popular, the economic, or other phase of the industry as required.
4. Youth Groups
   a. Boy Scouts — talk and demonstrations or foundry visit—encourage Scouts to earn merit badge in foundry practice and simplify task by setting up course for them.
   b. Hi-Y and similar groups—talks, demonstrations and foundry visits.

VI Lecture Courses

A. To train members of the chapter and other local foundrymen in the latest foundry practice and to acquaint them with A.F.A. literature.

B. Function of T.D.P. Staff

1. Prepare or secure lectures, slides, etc., from A.F.A. literature for presentation by local chapter members.

VII Exhibits

A. To exhibit anything related to the foundry industry for the interest and edification of the general public and special groups.

B. Entirely a function of local chapter.

1. Museums
   a. Temporary exhibits.
   b. Permanent, operating exhibits if possible.
2. Libraries
   a. Temporary exhibits, often arranged in connection with a display of foundry literature available at library.
   b. If library does not have all important A.F.A. literature give it or encourage its purchase.
3. Banks, utilities, large stores
   a. Exhibit may be general or may emphasize some feature related to displaying agency, such as dollar value of local industry to community.
4. Schools
   a. Exhibit general and on level with school children who are to view it.
   b. Exhibit special for science classes or vocational classes.
   c. Exhibit rotates among schools, and possibly libraries mentioned above.
5. Fairs, industrial shows, sportsmen's shows
   a. Exhibit general or suited to theme of gathering.
   b. Boy Scouts demonstrate foundry merit badge at county and state fairs.

VIII Foundation Lecture

A. To bring authoritative presentations of problems of the casting industry before the Association membership.

B. Responsibility of Annual Lecture Committee.

Foundry Personalities

● **Fred T. H. Youngman** has been appointed president, Jessop Steel Co., Washington, Pa. He was formerly vice-president of the company. **R. Edson Emery**, former president, was elected chairman of the board.

Eugene C. Bauer, president, Kensington Steel Co., Chicago, has been elected a director and vice-president, Poor & Co.

● **Ernest G. Jarvis,** president, Niagara Falls Smelting & Refining Corp., has assumed the office of acting president of Continental Industries, Inc., New York City, and its managerial affiliate, Continental Services, Inc.

John C. Patterson has been appointed executive vice-president of National Patent Council.

● **Joseph B. Terbell** has been appointed Executive Vice-President of American Brake Shoe's American Manganese Steel Division.

Horace A. Deane, works manager, Brake Shoe & Castings Div., American Brake Shoe Co., has been appointed a vice-president of the division.

● **Irving F. Wagner,** manager of American Brake Shoe's Kellogg plant, Rochester, N. Y., has been made a vice-president, Kellogg Division.

W. H. Moriarty has been made vice-president in charge of sales, National Malleable & Steel Castings Co., Cleveland. He was formerly assistant to the president.

● **W. J. Priestly** has been named vice-president in charge of alloys and metals division, Union Carbide & Carbon Corp., New York City.

Fred L. Wolf, formerly technical director, Ohio Brass Co., Mansfield, Ohio, later in charge of Graphite Crucibles and Graphite Production, WPB, Washington, D. C., and vice-president, Ross-Tacony Crucible Co., Philadelphia, who has just returned from a government-sponsored visit to Europe to study the non-ferrous metal situation there, has been appointed technical director, Non-Ferrous Ingot Metal Institute, Chicago.

Mr. Wolf has been a member of the A.F.A. for many years and was the recipient of the John A. Penton Gold Medal for his work on malleable iron.

● **B. J. Aamodt,** who has been prominent in the work of the A.F.A. Chicago chapter, has been advanced to manager of industrial sales, malleable and steel division, Melrose Park works, National Malleable & Steel Castings Co.

Max Robbins has been appointed general manager, Federated Metals Div., American Smelting & Refining Co., with headquarters in New York City.

● **Robert G. Allen** has been appointed general sales manager, The Baldwin Locomotive Works, Philadelphia.

H. M. Munson, formerly with Manning, Maxwell & Moore, Inc., Boston, has been appointed manager, industrial instruments division, Claud S. Gordon Co., Chicago.

● **Howard F. Taylor,** on leave of absence from the Naval Research Laboratory, Washington, D. C., is studying at Massachusetts Institute of Technology, Cambridge, Mass., for his doctorate.

Mr. Taylor is Chairman, Chesapeake chapter, and is well known to the industry through his talks before many technical societies and papers published in the trade press.

A. C. Conor, who served three years as an ensign with the U. S. Maritime Service and prior to that time was with the Standard Ultramarine Corp., Huntington, W. Va., has been named head of sales of resins and aromatic solvents, East Central section, Velsicol Corp., with headquarters at 1900 Euclid Ave., Cleveland.

H. F. Taylor

H. A. Deane

Max Robbins

W. J. Priestly

J. T. Parsons

B. J. Aamodt

● **J. T. Parsons** has been appointed district manager, Peninsular Grinding Wheel Co., Pittsburgh branch.

Thomas F. Davis, formerly chief metallurgist, Philadelphia works, General Electric Co., has been made district manager, The Beryllium Corp. of Pennsylvania, Reading, Pa., with offices in New York City.

● **Philip Rosenthal,** formerly with Battelle Memorial Institute, Columbus, Ohio, has been named Associate Professor of Metallurgy, University of Wisconsin, Madison, Wis.

Harold W. Lownie, Jr., formerly an engineer with Westinghouse Electric Corp., East Pittsburgh, Pa., has been named to the staff of Battelle Memorial Institute, Columbus, Ohio. He was a convention author for the 1945 Year-'Round Foundry Congress.

(Continued on Page 107)

CHAPTER ACTIVITIES News

CENTRAL ILLINOIS
Becomes 33rd A.F.A. "Baby" Chapter

WITH the unanimous approval of the A.F.A. Board of Directors, the A.F.A. stork flew down to Peoria, Ill., on December 17 to officiate at the birth of the thirty-third local group of American Foundrymen's Association, the Central Illinois chapter. Some 130 enthusiastic members of the foundry industry attended, in spite of pre-Christmas attractions, to see the famous cast iron rattle accepted by the Chapter Chairman Ed Roby, Jr., Peoria Malleable Castings Co., Peoria, Ill.

For a number of years interest has been growing toward formation of a local foundry group at Peoria and was advanced through the efforts of former National Director M. J. Gregory, then of Caterpillar Tractor Co. Early this fall, a group of foundrymen held a luncheon meeting at which it was decided to sound out the interest in the area in forming an official chapter. Accordingly, a petition was circulated and when completed, at an organizational meeting held in November, some 167 individuals signed the petition for chapter status.

As a result of the November meeting, a slate of officers was approved to serve until next spring when officers and directors will be officially elected. Thus Mr. Roby was elected chairman of the group for the interim period. Zig Madacey, Caterpillar Tractor Co., was elected *Vice-Chairman*; Carl W. Wade, Caterpillar Tractor Co., *Secretary*, and A. V. Martens, Pekin Foundry & Mfg. Co., Pekin, Ill., *Treasurer*.

Chairman Roby presided at the December 17 meeting at which time National Secretary W. W. Maloney, Chicago, declared the chapter officially installed. Past National Director Gregory recalled some earlier steps taken toward formation of the group, and urged the membership to play an active part in chapter programs. C. E. Von Luhrte, Chicago Retort & Fire Brick Co., Davenport, Iowa, and Chairman, Quad City chapter, expressed the best wishes of his chapter for the success of the new organization.

Speaker of the evening in December was Bruce L. Simpson, National Engineering Co., Chicago, who presented an outline depicting the development of the foundry industry from early antiquity to date. Illustrating his talk with slides, Mr. Simpson showed how the manufacture of castings has developed from strictly an art to a scientific basis and urged foundrymen to instill greater "pride of industry" among their employees.

Centrifugal Casting Process Is Expanding

THE centrifugal casting of ferrous and non-ferrous metals came in for an extensive discussion at the second meeting of the Metropolitan chapter, held at the Essex House, Newark, N. J., November 5.

Chapter Chairman Horace A. Deane, American Brake Shoe Co., New York, turned the meeting over to D. W. Talbot, vice-president and general manager, Copper Alloy Foundry Co., Hillside, N. J., who served as technical chairman and introduced Dr. Arthur E. Schuh, director of research, U. S. Pipe & Foundry Co., Burlington, N. J., the speaker of the evening.

"Centrifugal casting of metals is not a cureall of foundry trouble," declared Dr. Schuh, "but on work adaptable to the process, centrifugal casting offers a means of producing high quality castings at a low cost."

Dr. Schuh traced the history of the process from its beginning in 1807 to the experiments of Bessemer in 1850; the casting of iron car wheels in 1902 and the development of sand lined molds in 1920. He spoke of the work of the Watertown Arsenal where gun barrels 33 feet long and weighing 18 tons are being cast by the process.

The process expanded rapidly during the war period for four reasons: (1) Low capital investment; (2) Less time consumed in getting started as less equipment has to be obtained and installed; (3) High

Chapter Meetings January-February

January 16
Twin City
Curtis Hotel, Minneapolis
A. C. DEN BREEJEN
Hydro-Blast Corp.
"Practical Foundry Sand Problems"

✦ ✦

January 17
Detroit
Rackham Memorial
ROUND TABLE MEETING

✦ ✦

January 18
Birmingham
Tutwiler Hotel
QUIZ PROGRAM

✦

Toledo
Toledo Yacht Club

✦

Central Illinois
Jefferson Hotel, Peoria
J. A. GITZEN
Delta Oil Products Co.
"Chemical and Physical Properties of Core and Mold Binders"

✦ ✦

January 19
Western New York
Elk's Club, Buffalo
STAG PARTY

✦ ✦

January 21
Quad City
Fort Armstrong Hotel
Rock Island, Ill.
PROF. W. L. DAYKIN
University of Iowa
"Modern Relationship Between Top Management and Supervisor"

✦ ✦

January 22
Northern Illinois—Southern Wisconsin
Faust Hotel, Rockford, Ill.
"Labor Problems"

✦

Oregon
Heathman Hotel, Portland
"Electric Furnace Melting of Steel"

✦ ✦

January 24
Texas
San Antonio
J. A. KAYSER
Laclede-Christy Clay Products Co.
"Properties of Refractories"

✦ ✦

January 25
Chesapeake
Engineer's Club, Baltimore, Md.
W. C. WICK
Naval Research Laboratory
"Brass Gating"

Ontario
Royal Connaught Hotel, Hamilton
NATIONAL OFFICERS NIGHT
L. D. PRIDMORE
International Molding Machine Co.
"Core Blowing"

✦ ✦

January 28
Northwestern Pennsylvania
Moose Club, Erie
L. B. KNIGHT
Lester B. Knight & Associates
"Modernization in Foundries"

✦

Central Ohio
Fort Hayes Hotel, Columbus
ROUND TABLE MEETING

✦ ✦

February 1
Western New York
Hotel Touraine, Buffalo

✦ ✦

February 4
Central Indiana
Athenaeum, Indianapolis
C. E. WESTOVER
Westover Engineers
"Wage Incentives in the Foundry"

✦

Chicago
Chicago Bar Association
ROUND TABLE MEETING

✦

Metropolitan
Essex House, Newark, N. J.
ROUND TABLE MEETING

✦ ✦

February 5
Michiana
Hotel LaSalle, South Bend, Ind.
ROUND TABLE MEETING

✦ ✦

February 7
Saginaw Valley
Fischer's Hotel, Frankenmuth, Mich.
J. A. GITZEN
Delta Oil Products Co.
"Core and Mold Washes"

✦ ✦

February 7-8
Wisconsin
Schroeder Hotel, Milwaukee
REGIONAL CONFERENCE

✦ ✦

February 8
Philadelphia
Engineer's Club
H. F. TAYLOR
Naval Research Laboratory
"Gating and Risering"

✦

Eastern Canada and Newfoundland
Mount Royal Hotel, Montreal
GROUP MEETING

February 11
Cincinnati District
Engineering Society Headquarters
WM. B. GEORGE
R. Lavin & Sons
"Brass and Bronze Castings"

✦

Western Michigan
Schuler Hotel, Grand Haven, Mich.
NATHAN JANCO
Centrifugal Casting Machine Co.
"Centrifugal Castings"

✦ ✦

February 12
Rochester
Hotel Seneca
JOHN L. CARTER
Gray Iron Founders Society
"Foundry Costs"

✦ ✦

February 14
St. Louis District
DeSoto Hotel
NATIONAL OFFICERS NIGHT
J. H. VAN DEVENTER
Iron Age
"Let's Release the Brakes"

✦

Northern California
Hotel Alameda
N. J. DUNBECK
Eastern Clay Products, Inc.
"Sand"

✦ ✦

February 14-16
Birmingham District
Tutwiler Hotel
REGIONAL CONFERENCE

✦ ✦

February 15
Texas
Houston
A. J. EDGAR
Gray Iron Founders Society
"Controlled Operation"

✦

Toledo
Toledo Yacht Club

✦ ✦

February 20
Twin City
Curtis Hotel, Minneapolis
L. F. TUCKER
City Pattern Works
"Cooperation Between Patternmaker and Foundry"

✦ ✦

February 21
Detroit
Rackham Memorial
ROUND TABLE MEETING

✦

Canton District
Mergus Restaurant, Canton, Ohio
OLD TIMERS NIGHT AND ROUND TABLE

yields are obtained which average 60 to 80 per cent instead of 40 to 50 per cent as in the static process; and (4) High level of quality on work adapted to the process.

Dr. Schuh showed many slides illustrating various installations, machines and castings produced from the machines.

Dr. Schuh spoke briefly of the semi-centrifugal process and of the centrifugal process. Provisions for directional solidification must be obtained, for good quality semi-centrifugal castings are by the very nature of the process free of internal shrinks, however, the stock for finish on the inside diameter must be increased for heavy walled pipes.

The metal molds used in the true centrifugal process are sprayed with a refractory coating of .002 in. The coat serves two purposes in that it protects the mold and also gives traction to the pick-up of this fluid metal.

The speeds at which true centrifugal machines should operate are at about 1000 peripheral ft. per min. for metal mold and 1200 to 1500 peripheral ft. per min. for sand molds. Sand molds should be run longer on this machinery as the cooling process is slower. Too high a speed results in longitudinal cracks in the casting.

Dr. Schuh pointed to the new development of his company in the spinning of two or more metals in a single casting. He exhibited castings in which copper was poured immediately after steel, producing a steel pipe lined with copper. The fusion between the two metals was perfect and the fusion remained perfect after the pipe was drawn to ⅛-in. diameter. A composite steel and iron pipe also was shown.

COLLEGE WELCOMES

Texas Regional Conference Meeting

By R. B. Mumford, McArdle Equipment Co.,
Houston, Texas

THE first joint meeting of the Texas chapter and students of the Texas A & M College, was held in a two-day session on November 9-10 on the campus at College Station, Texas.

The initial conference was deemed a complete success by the participating mechanical and engineering students, as well as the association members and college faculty, and all parties are looking forward to the continuation of this type of meetings in the future. The program chairman, Wm. M. Ferguson, Texas Electric Steel Casting Co., Houston, together with National Director F. M. Wittlinger, Texas Electric Steel Casting Co., Houston, past chapter chairman, and Lloyd Berryman, Texas A & M College, must be commended on their combined efforts for having arranged such an interesting meeting for the mechanical and engineering students and the Texas foundrymen attending.

The meeting was formally opened under the gavel of Chapter Chairman Ed. Trout, Lufkin Foundry & Machine Co., Lufkin, in the Engineers Building, with about 20 foundrymen and 80 students in attendance. The Chairman presented the college with "Men in Progress," an early American engraved picture that was made in the year 1862, and which was accepted in behalf of the college by C. W. Crawford, Dean of Mechanical Engineering.

After the announcement of the program and the theme of the two-day session was announced, the Chapter Program Chairman, W. M. Ferguson, announced and introduced the speakers.

The first speaker was L. H. August, process engineer, Hughes Tool Co., Houston, who gave an illustrated paper on cast steel, recounting the problems of cast metals and classified and described the foundry practices as patterns and molding, melting, and heat-treatment.

Jack Klein, vice-president, Texas Foundries, Inc., Lufkin, followed with a paper on different practices involved in the melting and critical annealing processes of malleable iron.

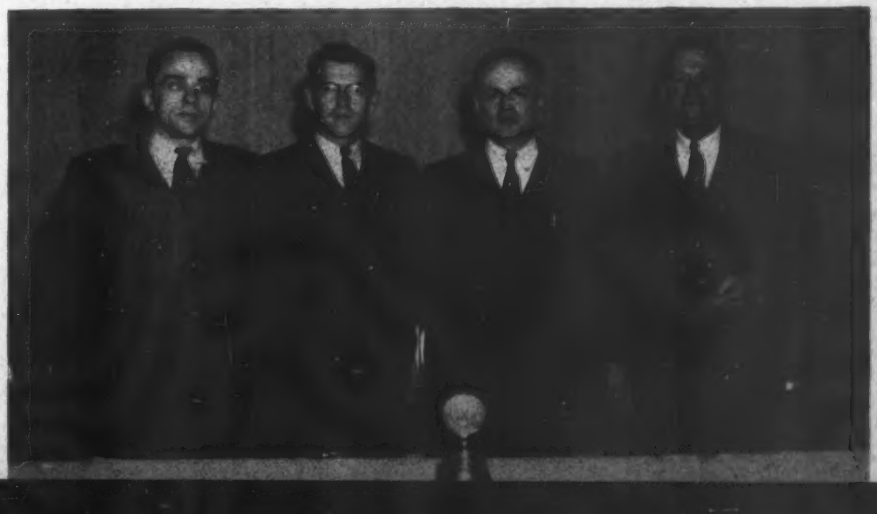
After a short recess, L. H. Roberts, president, Oil City Iron Works, Corsicana, talked on the general subject of iron, drawing to the attention of the students the need of production engineering and improvement of methods in the gray-iron industry, and described the trend of iron-making from an art to a science, opening up a large field for energetic new blood.

A colored film was next shown, illustrating the operation of the Belle City Malleable Iron Co., Racine, Wis., followed by a tour of inspection of the engineering laboratories at Texas A & M College by the chapter group, after which a recess was ordered until dinner.

A goodly number of students were in attendance at the dinner, as guests of the chapter, and Chapter Chairman Trout introduced a number of guests.

Following the dinner, F. M. Wittlinger presented the main speaker of the evening, Adrian Den Breejen, Hydro-Blast Corp., Chicago, whose subject was "Sand and Sand Problems in the Foundry In-

Chapter officers of the Northern Illinois-Southern Wisconsin chapter (left to right)—John Doerfner, Gunite Foundries Corp., Rockford, Ill., Treasurer; Art P. Rose, National Sewing Machine Co., Belvidere, Ill., Secretary; John R. Cochran, Sundstrand Machine Tool Co., Rockford, Ill., Chairman; and Gunnard Anderson, W. L. Davey Pump Corp., Rockford, Ill., Vice-Chairman.
(Photo courtesy John Bing, A. P. Green Fire Brick Co.)



dustry." His talk was illustrated and proved of great interest to all, and was followed by a general discussion, with the students taking an interested part.

Saturday morning's meeting was opened with the introduction of attending A.F.A. personnel, and was followed by an illustrated talk by R. E. Bockrath, Dow Chemical Co., Midland, Mich., on one of the newest of the metal industries, and described the magnesium industry and magnesium characteristics and its application into commercial fields, which proved of great interest to the foundrymen as well as the students.

The final paper was given by P. B. Croom, owner, Houston Pattern Works, Houston, on the pattern craft. His discourse stressed the importance of the patterns to foundry production and ultimately to the consumer, and detailed the types of patterns applicable to foundry practice and to the refinements of pattern construction as well as their classification.

Before adjournment, C. W. Crawford, on behalf of the college, thanked the chapter for their efforts in the presentation, and invited them to return as often as they could and repeat the educational program, which he felt was a great success.

ONTARIO CHAPTER

Sponsors Industrial Round Table

By G. L. White, Westman Publications Ltd., Toronto, Ont.

ONTARIO chapter held its second group meeting of the season at the Royal Connaught Hotel, Hamilton, on Friday, November 23. The dinner meeting, under the Chairmanship of T. D. Barnes, Don Barnes Foundry Supplies & Equipment, Hamilton, Ont., was followed by group meetings of the steel, non-ferrous, gray iron, and malleable sections.

The steel meeting was under the Chairmanship of Alex. Wilson, Fahralloy, Canada, Ltd., and the subject was "Water Quenching of Steel Castings."

C. W. Farrar, Fahralloy, Canada, Ltd., gave a brief outline of the history of water quenching from its commercial inception about thirty-seven years ago, and also discussed some of the effects of this treatment upon the properties of steel castings.

The second speaker, W. E. Loosley, Dominion Foundries & Steel, Ltd., discussed "Heat Treatment of Steel Castings," with particular reference to the types of furnaces and heating cycles employed.

L. F. Train, John Bertram & Sons Co., Ltd., Dundas, spoke on "Water Quenching in Relation to Design." He brought out the point that if a casting was properly designed for efficient production in the foundry, it was suitably designed for water quenching. Certain applications, where steel castings would be preferred to forgings if the manufacturer could rely on them being solid throughout, were mentioned.

In the non-ferrous group, under the Chairmanship of D. M. Loucks, St. Thomas Bronze Co., Ltd., Harold J. Roast, Canadian Bronze Co., Ltd., spoke on "Some Special Casting Problems." Mr. Roast had a number of exhibits, particularly of castings which had been made centrifugally.

The speaker described briefly the practice followed in making a number of centrifugal castings including gear blanks and other items. He also outlined a simplified heat treatment which was adopted on sealing collars of an alloy containing 85 per cent copper and 10 per cent aluminum. Instead of heating, quenching, and drawing as originally proposed, castings were poured at 2000° F. into green sand and were knocked out of the sand at the earliest possible moment after they had become solid. Excess sand was scraped off in order to hasten cooling and the castings given this simple heat treatment passed specifications with plenty of margin.

Chairman Wm. Prosse, Cockshutt Plow Co., Ltd., presided over the gray iron group and the speaker was G. J. Gaukroger, McKinnon Industries, Ltd., who led the discussion along lines of cupola and sand practice. The speaker stressed the need of accurate weighing of cupola material in order to keep the metal within chemical specification, and also to know proper melting costs. Where scales are used for weighing the charges, special equipment can be obtained which will record on tape the weights of the different melting materials. Totals can be computed on an adding machine at the end of the day.

The effects of materials on melting loss in cupola operation was discussed, and also the desirable yields for different classes of castings. Factors related to hot tears, and cracks in castings, were covered, including type of melting material, cupola operations, metal oxidation, humidity of the cupola blast and sand quality. Causes of scabs and buckles and their remedies both from the viewpoint of the molding sand and molding practice were discussed. It was suggested that high green strength, high moisture, low sea coal content, or too many fines in the sand were the chief cause, with hard mold ramming also a contributing factor.

At the malleable session, Charles Thompson, Galt Malleable Iron Co., Ltd., was chairman and the discussion leaders were J. J. McFadyen, Galt Malleable Iron Co., and A. Graham, Galt Testing Laboratories, with the subject, "Some Observations on Shrinkage Cracks and Hot Tears in Malleable Iron."

Division Meeting Is Popular At Montreal

By G. D. Turnbull, Canadian Car & Foundry Ltd., Montreal, Que.

THE monthly meeting of the Eastern Canada and Newfoundland chapter was held November 9 at the Mount Royal Hotel, Montreal.

The iron and steel meetings were merged into a single group under the Chairmanship of J. Grieve, Dominion Engineering Works Ltd. The discussion leaders were J. McVey, Jenkins Bros. Ltd., who talked on "Production Methods" and E. Turner, Lynn MacLeod Metallurgy Ltd., who discussed "Steel Foundry

Technology." An interesting discussion and question period followed the speakers.

The non-ferrous group convened under the Chairmanship of A. J. Moore, Montreal Bronze Ltd. The discussion leaders were Marc Chicoine, Robert Mitchell Co. Ltd., who spoke on "Melting and Alloying" and H. J. Roast, Canadian Bronze Co. Ltd., on "Special Casting Problems." During the subsequent discussion many important points were brought out with regards to charge make-up and melting atmospheres and also how centrifugal casting methods helped to solve certain difficult casting problems.

The miscellaneous group meeting was presided over by A. E. Cartwright, Robert Mitchell Co. Ltd. The subject discussed was "Salvage and Repair of Castings." A. E. Speck, Dominion Oxygen Co. Ltd., assisted Mr. Cartwright in explaining how progress in welding now made possible the reclaiming of castings.

Eastern Canada Chapter Presents French Meeting

By G. D. Turnbull,
Canadian Car & Foundry Ltd.,
Montreal, Que.

A MEETING of the Eastern Canada and Newfoundland chapter was held at Quebec, November 2, at the Arts and Crafts School. This program was organized and presented for the benefit of the French speaking members and technical school students and was presented entirely in French. The committee in charge consisted of Chairman Del. Allard, Dir. School of Aviation, Provincial Government, Montreal; Vice-Chairman E. Laurendeau, Dominion Engineering Works Ltd., Montreal; Henri Louette, Warden King, Ltd., Montreal; and Robert Bernard, La Cie J. A. Gosselin, Ltée., Drummondville.

The afternoon session was opened with an address of welcome to all members and visitors. This was delivered by Philippe Méthé, director of the school, and he invited all those present to visit the various school shops. The tour through the school presented an opportunity for the members to view how and in what courses the students were being instructed.

Re-assemblying in the lecture hall, the meeting was addressed by E. C. Winsborrow, vice-president, Shawinigan Foundries, Ltd., on "Technical Advice to Young Foundrymen." The following speaker, Emile Drolet, president, F. X. Drolet, Ltd., talked on "Metallurgy." Chairman Del. Allard spoke on what the Arts and Crafts School is attempting to do in the province with respect to broadening the technical education. The group then adjourned to the shops of F. X. Drolet, Ltd., for a plant visit.

Henri Louette, vice-chairman, Eastern Canada and Newfoundland chapter, was the evening speaker. His well illustrated discussion of "Foundry Sands" was received enthusiastically.

Patternmaking Through The Help of Cement

By H. B. Voorhees,
Dodge Mfg. Co.,
Mishawaka, Ind.

CHAPTER CHAIRMAN W. V. SPEARS, Oliver Farm Equipment Co., South Bend, Ind., presided over the November 6 meeting of the Michiana chapter held at the LaSalle Hotel, South Bend, Ind.

James Jehring, district representative, Purdue University, Lafayette, Ind., gave a ten minute coffee talk on a new idea on American education.

E. H. Schleede, U. S. Gypsum Co., Chicago, was the guest speaker and was introduced by Leonard Tucker, City Pattern Works, South Bend. The topic presented was "Patternmaking with Gypsum Cements." A sound slide film was used by Mr. Schleede to explain how these materials are used for patternmaking. A practical demonstration then followed when the speaker mixed the cement with water and made a composition used for patternmaking. He stressed the need for paying particular attention to the amount of water added and the method of stirring and mixing.

Northern California Outing at Mira Vista

By J. F. Aicher,
E. A. Wilcox Co.,
San Francisco

SOME of Northern California's most enthusiastic golfers participated in the Northern California chapter Annual Golf Party held October 18 at the Mira Vista Country Club, San Francisco. Horseshoe pitching held the interest of those who refused to chase the golf ball over hill and dale. In the evening a meal was served to the members, and the prize winners were announced.

Southern California Enjoys Party Banquet

By Jas. B. Morey,
International Nickel Co.,
Los Angeles

SATURDAY evening, December 8, approximately 340 members and guests assembled at the Lakewood Country Club, Long Beach, to enjoy the annual Southern California chapter Christmas party. The banquet was well received, as was the peppy floor show which followed.

Officers and directors of the Northwestern Pennsylvania chapter had this picture taken at a recent chapter meeting. Seated (left to right)—Ray Britton, Urick Foundry Co., Erie, Treasurer; H. L. Gebhardt, United Oil Mfg. Co., Erie, Secretary; Roger W. Griswold, Jr., Griswold Mfg. Co., Erie, Chairman; Earl Strick, Erie Malleable Iron Co., Erie, Vice-Chairman; Ralph Wedgwood, Pickands Mather & Co., Erie, Director; and L. A. Dunn, General Electric Co., Erie, Director. Standing (left to right)—Kenneth Guyer, Bucyrus-Erie Co., Erie, Director; LeGrand Skinner, Skinner Engine Co., Erie, Director; J. Douglas James, Erie City Iron Works, Erie, Director; J. S. Hornstein, Meadville Malleable Iron Co., Meadville, Director; J. H. Beaulac, Chicago Pneumatic Tool Co., Franklin, Director; Wm. Miller, Frederic B. Stevens, Inc., Erie, Director; and Clarence Fitz, Hays Mfg. Co., Erie, Director.
(Photo courtesy Earl M. Strick, Erie Malleable Iron Co.)

NINTH ANNUAL
Wisconsin Conference in February

THE Ninth Annual Regional Foundry Conference under the joint auspices of the Wisconsin chapter and the University of Wisconsin, Madison, Wis., will be held at the Schroeder Hotel, Milwaukee, on Thursday and Friday, February 7 and 8.

Beginning with the opening address by F. Ellis Johnson, dean, College of Engineering, University of Wisconsin, a wide variety of subjects including metallurgical, foundry, core, pattern and production problems will be presented by speakers especially well qualified in their respective fields. There will be 24 separate sectional meetings, four each for the steel, malleable, gray iron, non-ferrous, pattern and technical groups.

In addition there will be two general meetings, one on foundry costs and another describing, through colored movies, a metallurgist's view of modern Europe.

For the luncheon and dinner meetings, speakers of national repute have been secured for addresses of general interest including Strickland Gillilan, one of America's best

WISCONSIN CHAPTER
NINTH ANNUAL CONFERENCE
PROGRAM SCHEDULE
Schroeder Hotel, Milwaukee, February 7-8

Thursday, February 7

9 am—Registration

10 am-10:30 am—Opening Address
Speaker, Dean F. Ellis Johnson, University of Wisconsin, Madison, Wis.

10:30 am-12 noon—Foundry Costs
Speaker, Ralph Lee, Grede Foundries, Inc., Milwaukee

12 noon—Luncheon Meeting
Speaker, Dr. E. B. Fred, President, University of Wisconsin, Madison, Wis.

2 pm-3:30 pm—Steel
Speaker, E. C. Jeter, Ford Motor Co., Detroit
"Sand Reclamation"

2 pm-3:30 pm—Gray Iron
Speaker, Ralph Clark, Electro Metallurgical Co., New York
"Cupola Operation"

2 pm-3:30 pm—Malleable
Speaker, James H. Lansing, Malleable Founders Society, Cleveland
"Report on Annealing"

2 pm-3:30 pm—Non-Ferrous
Speaker, Nathan Janco, Centrifugal Casting Machine Co., Tulsa, Okla.
"Defects in Non-Ferrous Centrifugal Castings and Their Elimination"

2 pm-3:30 pm—Pattern
Speaker, Paul Riedel, Production Pattern Co., Milwaukee
"Core Blowing Equipment"

2 pm-3:30 pm—Technical
Speaker, George Watson, Electro Metallurgical Co., Chicago
"Effects of Alloys in Ferrous Metals"

3:40 pm-5:10 pm—Steel
Speaker, Howard Taylor, Naval Research Laboratory, Washington, D. C.
"Steel Foundry Practice"

3:40 pm-5:10 pm—Gray Iron
Speakers, A. Lebesch, Allis Chalmers Mfg. Co., West Allis, Wis.; F. Kulka, Motor Castings Co., Milwaukee; and Paul Woehlke, Grede Foundries, Inc., Milwaukee
"Scrap Clinic"

3:40 pm-5:10 pm—Malleable
Speaker, James H. Lansing, Malleable Founders Society, Cleveland
"Study of Present Annealing Methods"

3:40 pm-5:10 pm—Non-Ferrous

3:40 pm-5:10 pm—Pattern
Speaker, V. J. Sedlon, Master Pattern Co., Cleveland
"Permanent Molds"

3:40 pm-5:10 pm—Technical

6:30 pm—Banquet
Speaker, Strickland Gillilan, Washington political observer
"The Low Down on Washington High Ups"

Friday, February 8

10 am-12 noon—Steel
Speaker, Prof. George Barker, University of Wisconsin, Madison, Wis.
"Steel Foundry Metallurgy"

10 am-12 noon—Gray Iron
Speaker, W. A. Hambley, Allis Chalmers Mfg. Co., West Allis, Wis.
"Metallurgy for Practical Foundrymen"

10 am-12 noon—Malleable
Speaker, L. R. Shocken, Wm. H. Nicholls Co., Long Island, N. Y.
"Malleable Casting Production by Automatic Molding Machines"

10 am-12 noon—Non-Ferrous
Speaker, Wm. George, R. Lavin & Sons, Inc., Chicago
"Non-Ferrous Foundry Practice"

10 am-12 noon—Pattern
Speaker, A. F. Pfeiffer, Allis Chalmers Mfg. Co., West Allis, Wis.
"Pattern and Casting Engineering"

10 am-12 noon—Technical
Joint meeting with Steel group

12 noon—Luncheon Meeting

2 pm-3:30 pm—Steel
Speaker, Dr. J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala.
"Centrifugal Casting in Nazi Germany"

2 pm-3:30 pm—Gray Iron
Speaker, H. F. Scobie, American Foundrymen's Association, Chicago
"Practical Control for the Small Foundry"

2 pm-3:30 pm—Malleable
Speaker, Frank Lepour, Belle City Malleable Co., Racine, Wis.
"Duplexing Malleable Iron"

2 pm-3:30 pm—Non-Ferrous
Speakers, Dr. Blake Loring and Wm. Baer, Naval Research Laboratory, Washington, D. C.
"Radiographic Detection of Flaws in Tin Bronze Castings"

2 pm-3:30 pm—Pattern
Speaker, Wm. C. Kohler, Scientific Cast Products Co., Cleveland
"Making Pressure Cast Plates and New Pattern Equipment Methods"

2 pm-3:30 pm—Technical
Joint meeting with Non-Ferrous group

3:40 pm-5:10 pm—General Meeting
Speaker, Carl Thieme, H. Kramer & Co., Chicago
"A Metallurgist Views Europe from Beaches to Berlin"

known humorists, who will present the "Low Down on the High Ups at Washington."

David Zuege, Sivyer Steel Casting Co., Milwaukee, is chairman of the conference committee. Russel Anderson, Belle City Malleable Co., Racine, Wis., is co-chairman, and Professors E. R. Shorey and George Barker, University of Wisconsin, are associate chairmen.

The complete program appears on the opposite page.

Consumers to Demand Improved Properties

By Lt. (j.g.) John T. Robertson, Naval Research Laboratory, Washington, D. C.

THE Chesapeake chapter presented F. W. Hanson, metallurgist, Electro Metallurgical Co., New York, who spoke on "Alloys in Gray Iron" at the meeting held on November 23 at the Engineers Club, Baltimore.

Mr. Hanson first pointed out that peacetime consumers would demand that the rapid foundry progress, brought by war production, be applied now in order to continue improved mechanical properties, structure, dimensional stability; and increased resistance to heat, abrasion and oxidation. The speaker then showed a series of slides dealing with the use of inoculants for the general improvement of the properties of gray iron.

Robinson and National Officers Meet at Erie

By E. H. Fiesinger, Jr., Urick Foundry Co., Erie, Pa.

NATIONAL Officers Night, along with an address delivered by L. P. Robinson, W. G. Smith Co., Cleveland, featured the November 26 meeting of the Northwestern Pennsylvania chapter held at the Moose Club, Erie, Pa. On hand to represent A.F.A. were National President Fred J. Walls, International Nickel Co., Detroit; National Director R. T. Rycroft, Jewell Alloy & Malleable Co., Inc., Buffalo, N. Y.; and National Secretary Wm. W. Maloney, Chicago.

Mr. Robinson presented a very interesting and enlightening talk on "Variables in the Core Room."

President Walls also addressed the membership with "The Foundry Is the Beginning of Everything Made" as his subject.

National Secretary Maloney commented upon the forthcoming A.F.A. 50th Anniversary Convention and Exhibit to be held in Cleveland, May 6-10, 1946.

Sectional Meeting Brings An Interchange of Ideas

By G. L. White, Westman Publications Ltd., Toronto, Ont.

WITH about 125 in attendance the Ontario chapter held a very successful group meeting at the Royal York Hotel, Toronto, Ont., on October 25.

Present at the head table on this occasion were a number of the men who played a very important part in the founding and early development of Ontario chapter. Included in this group were Major L. L. Anthes, Anthes Imperial, Ltd., Toronto; S. R. Francis, Metals & Alloys, Ltd., Toronto; and D. J. Macdonald, Standard Sanitary & Dominion Radiator, Ltd., Toronto.

Chairman T. D. Barnes, Don Barnes Foundry Supplies & Equipment, Ltd., Hamilton, called upon each of the three for a few words in which they emphasized the development of the Ontario chapter from the time of the first meeting when approximately 17 persons attended.

At the gray iron section, under the chairmanship of Andrew Reyburn, Massey-Harris Co., Ltd., Toronto, the discussion leaders were G. J. Gaukroger, McKinnon Industries Ltd., St. Catherines, and W. J. Brill, Canadian General Electric Co., Ltd., Toronto. One subject which received considerable attention was cupola practice. Various techniques of lining and operating were outlined, and a lively exchange of ideas on the subject of forcing cupolas took place. The contour lining of cupolas was mentioned but had not been tried by any of the foundrymen present. It was the opinion of the majority that it is far better to have a large cupola and melt under capacity, than to use a slightly smaller lined cupola at a production over the rated maximum.

Coke consumption and ratios were discussed by J. Wotherspoon, Anthes Imperial, Ltd. Mr. Reyburn made a few remarks on the practice followed in the new foundry of Massey-Harris Co., Ltd., Brantford, in respect to sand. He was of the opinion that a great deal could be done to improve sand control in jobbing foundries operating entirely with heap sand.

George Bruce, Beatty Bros., Ltd., Fergus, was chairman of the nonferrous session and the subject was "A Mechanized Brass Foundry" by Thomas Lyons, Empire Brass Mfg. Co., Ltd., London.

The speaker pointed out that the requirements of war production, coupled with short supply of labor, made necessary the simplification of work to use inexperienced help, and the increase of production with the same amount of labor and floor space.

Mr. Lyons described the mech-

(Photo courtesy Earl M. Strick, Erie Malleable Iron Co.)

Foundry management representatives present at a luncheon sponsored by the Northwestern Pennsylvania chapter. This gathering heard National President Fred J. Walls, International Nickel Co., Detroit; National Secretary W. W. Maloney, Chicago; and National Director R. T. Rycroft, Jewell Alloy & Malleable Co., Inc., Buffalo, N. Y., speak on Association work and activity.

anization plan which was started by his company early in 1944 and which was carried through with only one week's loss of production time. Within a short time after completion of the installation, production at the plant was increased by about 80 per cent. The speaker described in some detail the principal mechanical features which had enabled the foundry to achieve this success in production.

The malleable group, under the Chairmanship of E. G. Storie, Fittings Ltd., Oshawa, J. J. McFadyen, Galt Malleable Iron Co., Ltd., Galt, spoke on "Some Observations in Mechanized Foundries."

Cupola Practice Heard By New England Members

By Merton A. Hosmer, President, New England Foundrymen's Association, Boston

THE monthly meeting of the New England Foundrymen's Association was held at the Engineer's Club, Boston, on November 14, with over a hundred members and guests present.

The guest speaker was T. G. Johnson, metallurgical engineer, Pig Iron and By-Products Div., Republic Steel Corp., Cleveland. He addressed the members on "Cupola Practice," a very popular subject among New England foundrymen.

With a series of very ingenious diagrams on the blackboard, Mr. Johnson showed the action taking place within a cupola in the various zones with particular reference to chemical reactions. He called attention to the necessity of watching the quality of coke used, stating that this is a most important item in making good iron. Each foundry must determine correct size of coke for each cupola and see that the correct size is used in order to get the best results for each melting unit.

An effort also should be made to carry a uniform moisture content in the air throughout the year, he said.

A prolonged discussion followed the address and various subjects came up from pig iron to refractories.

Above—Anxiously awaiting the dessert after the fine meal at the Southern California chapter Christmas party are (left to right): Earl Anderson, Enterprise Iron Works; Jim Eppley, Kinney Iron Works; Hal Russill, chapter secretary, Eld Metal Co., Ltd.; Bob Haley, chapter president, Advance Aluminum & Brass Co.; Bill Emmett, chapter vice-president, Los Angeles Steel Casting Co.; Jack Coffman, Los Angeles Steel Casting Co.; J. F. Cassel, Compton Metals and L. O. Hofstetter, Brumley-Donaldson Co. Below—Members of the Entertainment Committee are (seated, left to right): Roy Barner, Snyder Foundry Supply Co.; George Emmett, Los Angeles Steel Casting Co.; Charlie McGraw, Long Beach Brass Foundry; Myron Niesley, California Testing Laboratories, Inc.; and H. G. Pagenkoff, Angeles Pattern Works. Standing (left to right)—H. Bierley, Production Pattern & Mfg. Co.; Chas. Lamb, Independent Foundry Supply Co.; Fred Tomaseck, I. H. Raber Co.; Franke Burke, Allied Castings Co.; and Committee Chairman Earl Shomaker, Kay-Brunner Steel Products, Inc.

Round Table Session Holds Three Subjects

By L. A. Merryman, Tonawanda Iron Corp., No. Tonawanda, N. Y.

THREE groups of Western New York chapter members assembled in separate rooms at the Hotel Touraine, Buffalo, N. Y., November 2, to hold a round table conference.

"Cupola Practice" was discussed at one session under the leadership of Carl A. Harmon, Hanna Furnace Corp., Buffalo, N. Y. The principal phases of the subject were outlined by the speaker from the selection of raw materials and methods of charging to slagging and patching.

Walter Crafts, Union Carbide & Carbon Research Laboratories, Niagara Falls, N. Y., handled "Steel Foundry Melting Practices." He re-

Pictures taken at the November meeting of the Northern Illinois-Southern Wisconsin chapter. *(Photos courtesy John Bing, A. P. Green Fire Brick Co.)*

viewed metallic charges, slag practices and control, oxidation practice and deoxidation in the furnace and ladle.

The application of various alloys in aluminum castings and their effect on machinability, heat treating and the practice of making pilot castings for large jobs was covered by Robert W. Molley, Foundry Metal Sales, Buffalo, N. Y. His topic, "Non-Ferrous Practice," was well received.

An added feature of the evening was a coffee talk by Max T. Ganzauge, General Railway Signal Co., Rochester, N. Y. The speaker presented some highlights of his trip into Germany following V-E day. He was appointed by the Foreign Economic Administration to make a technical survey of German foundry facilities and practices.

National Officers and Knight Before Toledo

By R. B. Bunting,
Bunting Brass & Bronze Co.,
Toledo, Ohio

NOVEMBER dinner meeting of the Toledo chapter was held at the Toledo Yacht Club with a number of National officers present. National President Fred Walls, International Nickel Co., Detroit; National Director R. T. Rycroft, Jewell Alloy & Malleable Co., Inc., Buffalo, N. Y.; and National Secretary Wm. W. Maloney, Chicago, spoke briefly to the membership.

The speaker of the evening was Lester B. Knight, Lester B. Knight & Associates, Chicago. His subject, "The Modernization of the Foundry," was constructive and well illustrated.

Mr. Knight offered a direct challenge to foundrymen in his talk. In his opinion much of the foundrymen's woes are the fault of the foundryman. In order to progress a foundry must keep abreast of modern developments — modern thinking is needed more than modern equipment. He emphasized the need for establishing and maintaining control of all foundry procedures and controlling of foundry costs to insure profit.

A meeting was held in the afternoon at the Commodore Perry Hotel at which time the National officers addressed representatives of top management. Short talks were made stressing the benefits management derives from membership in A.F.A., and also the benefits their employees and supervisors receive by attending local chapter meetings.

Group Sessions Feature November Canton Meeting

By Nils E. Moore,
Wadsworth Testing Laboratory,
Canton, Ohio

SECOND in a series of five talks on "Job Evaluation" was presented by Conrad Traut, Hoover Co., Canton, Ohio, at the November 29 meeting of the Canton District chapter. Seventy-two members and guests met at the Elks Club, Alliance, Ohio, to hear Mr. Traut and to participate in the group sessions that followed.

Lewis Way, Columbiana Foundry Co., Columbiana, Ohio, led the cast iron group in a discussion of cupola practice.

At the steel meeting I. M. Emery, Massillon Steel Casting Co., Massillon, Ohio, acted as discussion leader.

Presiding over the pattern group was John Dickerson, The Pitcairn Co., Barberton, Ohio.

Non-ferrous men heard M. G. Winters, Winters Foundry & Machine Co., Canton, Ohio.

The Time and Motion Study

Over 300 members and guests attended the annual Christmas party held by the Southern California chapter at Lakewood Country Club, Long Beach. Top (left to right)—Andrew Conahan and Gilbert Extels, General Electric Co., Ontario, and Emile Boudraeux, Douglas Aircraft Co. Center (left to right)—M. E. Dickens, John Janca, G. H. Dickard and R. E. Benjamin, Westlectric Castings, Inc., East Los Angeles. Bottom—M. J. Oberlies, Allied Castings Co., (left) and Dick Hughes, Almquist Bros. & Viets, Los Angeles.

group assembled to hear M. B. Hoffman, Norris Elliot Co., Canton, Ohio.

Directory Published By Michiana Chapter

PRESENTED to the Michiana chapter membership at a current meeting was a chapter directory. This booklet contains the complete membership list as of October 1, 1945. The chapter's 1945-46 program is listed as well as its officers and directors.

Program Schedule For Birmingham Conference

MEETING at the Tutwiler Hotel, Birmingham, Ala., the Birmingham District chapter will sponsor its annual regional conference Feb. 14-16.

The first sessions will be held Thursday followed by additional meetings and plant visitation on Friday. The final session scheduled for Saturday is listed as a plant visitation.

Technical speakers will include B. L. Simpson, National Engineering Co., Chicago; L. P. Robinson, Werner G. Smith Co., Cleveland; F. L. Overstreet, Illinois Clay Products Co., Joliet, Ill., and other well known foundry engineers. Banquet speaker for Friday evening will be Milton H. Fies. National President Fred J. Walls, International Nickel Co., Detroit, will speak at the luncheon on Thursday.

Schedule of sessions is shown below.

Birmingham Regional Conference Schedule of Sessions

Tutwiler Hotel, Birmingham, Ala.

Thursday, Feb. 14

9 am—Registration
10:30 am—Technical Session
12:30 pm—Luncheon
2:30 pm—Technical Session
4 pm—Technical Session
7:30 pm—Entertainment

Friday, Feb. 15

9 am—Plant visitation
2 pm—Technical Session
3:30 pm—Technical Session
7 pm—Annual Banquet

Saturday, Feb. 16

Plant Visitation

Southern California to Start Lectures January

STARTING Monday evening, January 28, and each succeeding Monday evening until February 25, the Southern California chapter will be conducting their annual lecture course. This year the course comes under the chairmanship of John E. Wilson, Climax Molybdenum Co., Los Angeles.

The outline of the course is as follows: Lecture No. 1, E. K. Smith, metallurgical consultant, Beverly Hills, Specifications; Lecture No. 2, J. A. Burgard, Columbia Steel Corp., Los Angeles, Patterns; Lecture No. 3, N. J. Dunbeck, Eastern Clay Products, Inc., Eifort, Ohio, Mold and Core Materials; Lecture No. 4, Fred Sefing, International Nickel Co., New York, Gating and Risering Practice; and Lecture No. 5, Edward G. Smyth, Standard Oil of California, Los Angeles, and C. E. Lloyd, Consolidated Steel Corp., Shipbuilding Div., San Pedro, Calif., Inspection and Repairs.

Chicago Resumes Lecture Course Series in January

SIX lectures and a tour through the Museum of Science & Industry, Chicago, will comprise the 1946 Lecture Course program sponsored by the Chicago chapter. Subjects will cover current foundry problems and techniques and will touch upon many phases of foundry practice. The lectures, to be held every Monday evening starting January 14, will be presented by outstanding foundrymen, engineers and metallurgists. All lectures will be held in the Peoples Gas Building Auditorium as in previous years.

The first lecture will be on patterns for high production; second, molding materials; third and fourth, molding methods; fifth, foundry layout and planning and sixth, defective castings—cause and cure. A specially conducted tour through the Museum of Science & Industry will conclude the course.

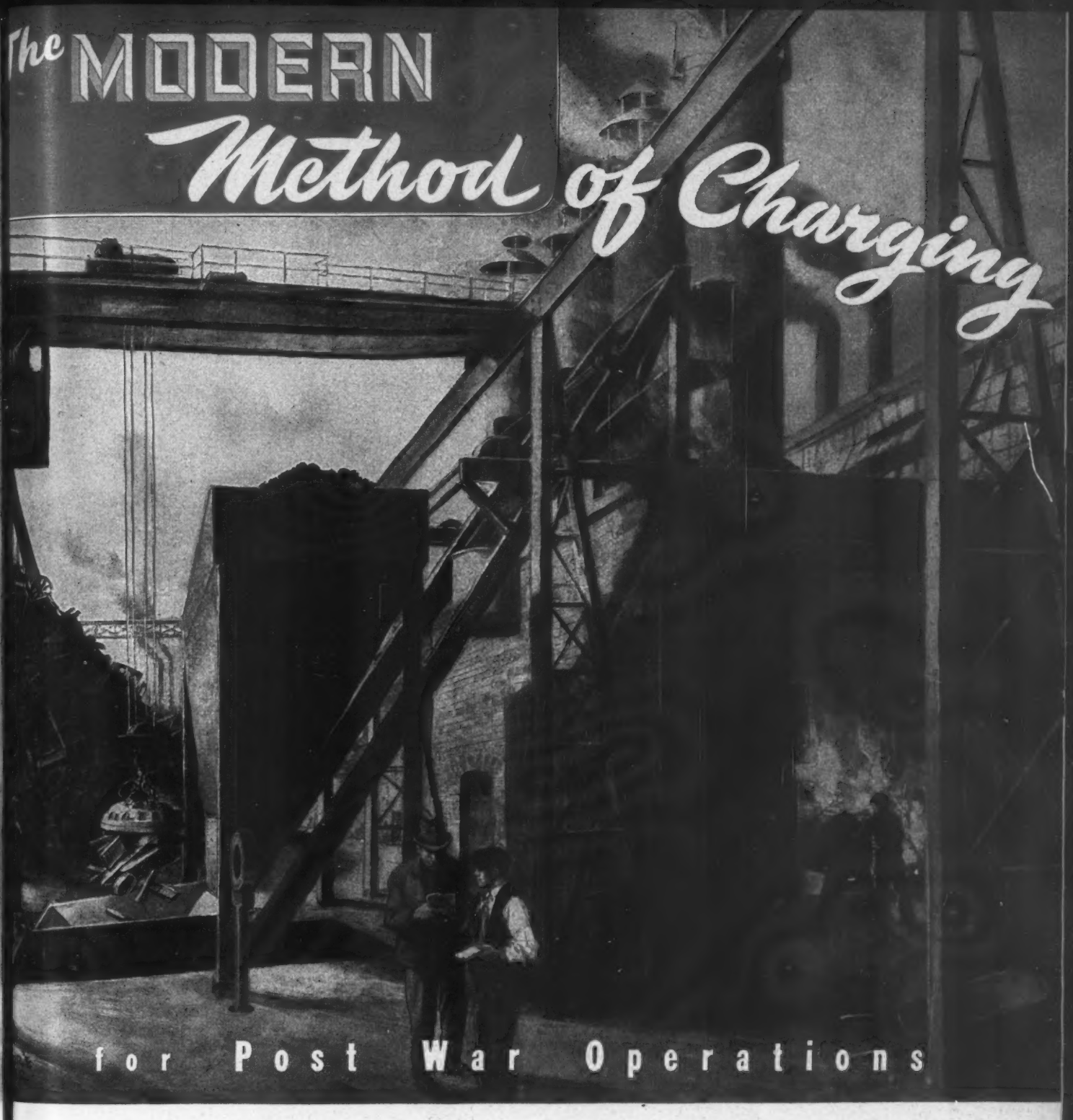
Wisconsin chapter pictures taken at the October and November meetings.
(Photos courtesy John Bing, A. P. Green Fire Brick Co.)

Round Table Sponsored By Central Ohio Group

By K. Whitlatch,
Aetna Fire Brick Co.,
Oak Hill, Ohio

THE experiment conducted by the Central Ohio chapter at their November 26 meeting in regards to round table meetings turned out a big success. The 85 members and guests present at the Fort Hayes Hotel, Columbus, Ohio, participated in the tri-meeting.

The subject chosen for all three groups was "Core Room Practice." The leaders of the sessions were: gray iron, K. G. Presser, chief metallurgist, National Supply Co., Springfield, Ohio; non-ferrous, W. R. Huffman, plant manager, H. B. Salter Mfg. Co., Marysville, Ohio; and steel, Delmar S. Kolleda, Commercial Steel Casting Co., Marion, Ohio.



Foremost foundry operators are now laying their plans for the necessary post-war efficiency.

For charging efficiency, they are including in their programs *Modern Cupola Chargers*—both for economy in operation and best melting control. For the Modern Drop Bottom Bucket lays in a charge perfectly stratified equal to the best of hand charging.

Highest efficiency can be obtained with the magnet crane arrangement shown above. The charger unit is swiveled to serve the four cupolas above, two simultaneously. Other models furnished for cupolas of all sizes.

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READY, because Federated has no reconversion problem. The same superb quality aluminum, brass, bronze, babbitt, die-cast alloys, solder and zinc dust that yesterday went into war material are ready today for civilian products.

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With these expanded means we are ready to serve American industry's future — a future brightened by many new products, conveniences and comforts for a higher standard of living.

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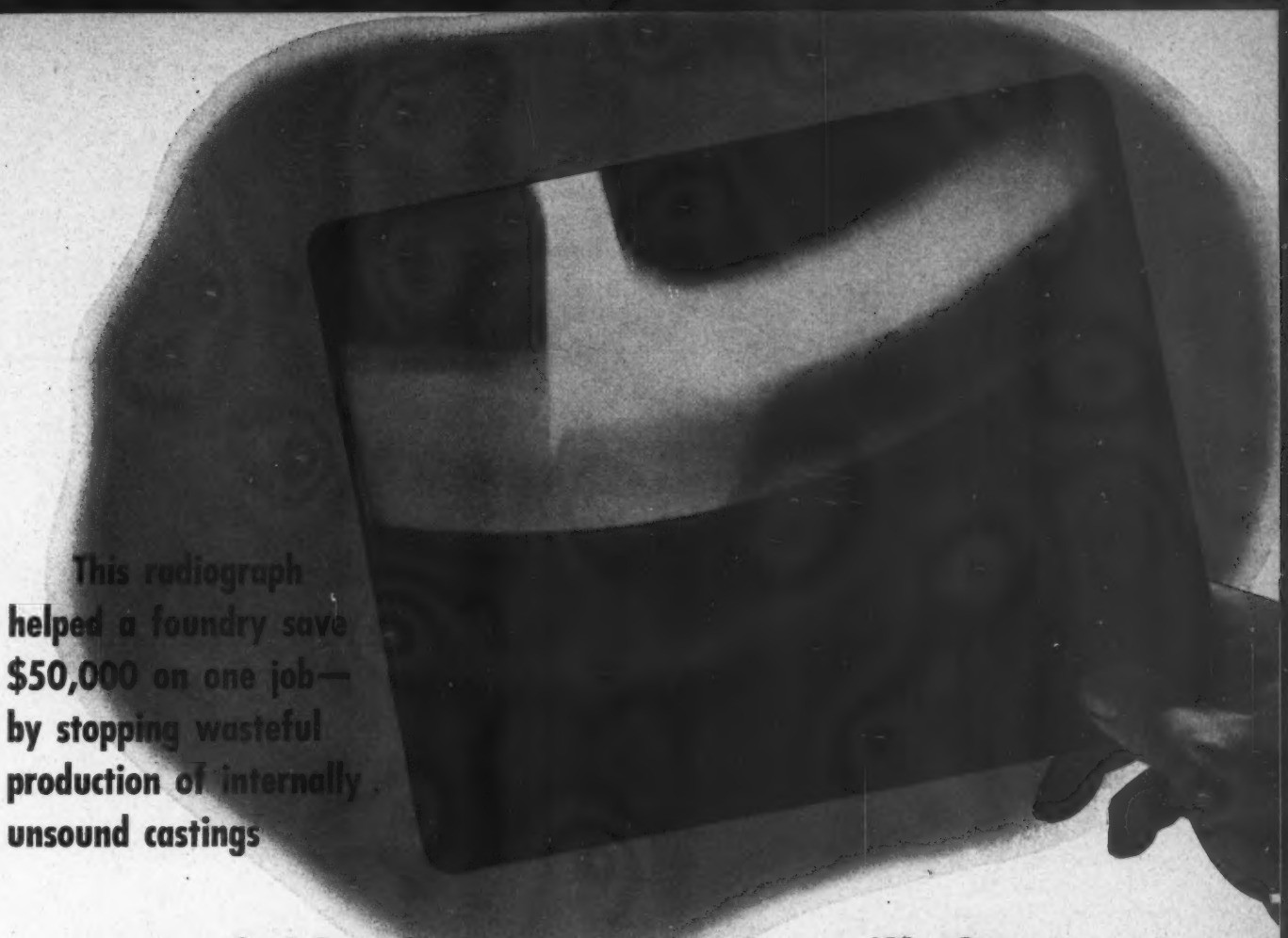
Nation-wide service with offices in principal cities



This radiograph helped a foundry save $50,000 on one job— by stopping wasteful production of internally unsound castings

a careful look at your costs will show you how much Radiography can save you

ONLY YOU can determine where and how radiography can be profitable in your foundry. It will pay you to take a careful look at your present production methods . . . at losses you've been charging to overhead. For example . . .

In the foundry, radiography can indicate more efficient technics to get your plant into production faster . . . can help you produce consistently sound castings from start to finish. This will cut customer rejects, lower costs, and bring repeated re-orders. It will also attract more new business—business you'll need later.

If you do machining, radiography can eliminate the man-hours and machine time wasted on internally unsound castings. Even the most modern machine tools can't give fast, efficient, low-cost production if you let internally unsound castings get into your shop.

And, if you have a welding shop, radiography can be a great help to you in making welding repairs to castings . . . can create acceptance for your weldments . . . enables you to compete for work on high-pressure equipment and other jobs where radiographic inspection of weldments is mandatory.

Radiography does other things, too. It shows your designers how to reduce weight safely . . . helps your engineers specify less costly processing technics . . . guides your fabricators to better construction methods.

Why not get your x-ray dealer to show you now—how radiography can help you cut overhead, increase production, build better products. Or write to

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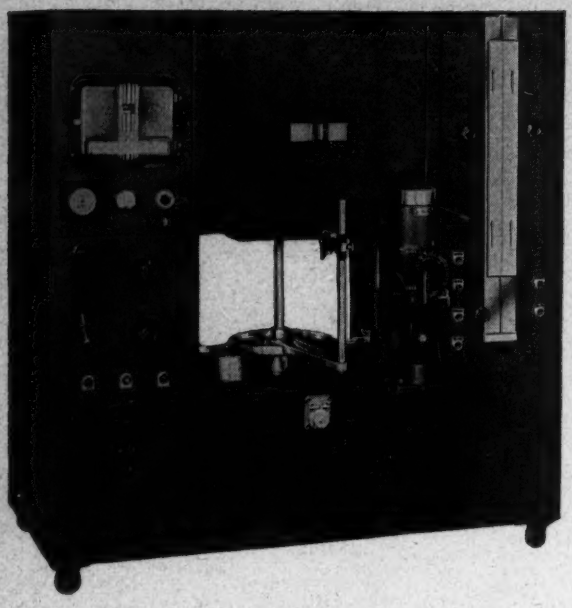

KNOW IN ADVANCE HOW YOUR SAND WILL BEHAVE AT METAL POURING TEMPERATURES

THE HITEMP DILATOMETER helps you determine the causes of such defects as rat tails, scabs, buckles, fissures, veining, hot tears, metal penetration, oxide penetration, blows, dirt inclusion and cuts.

Accessories provided to conduct the following tests:

1. Hot spalling test
2. Hot shrinkage test
3. Expansion-contraction test
4. Hot strength test
5. Hot deformation test
6. Hot gas pressure test
7. Mold atmosphere test
8. Oxide-metal penetration test
9. Own atmosphere tests
10. Hot collapsibility test
11. Refractoriness visual test
12. Hot permeability determination
13. Protective coating visual test
14. Hot gas volume determination

High Temperature Testing Helps Produce Better Castings

HIGH TEMPERATURE TESTING of molding sands, cores, protective coatings and refractories, provides practical test data to both the technical and operating staffs.

A gas-tight observation port on the Hitemp Dilatometer permits the operator to visually observe how these important materials behave at *metal pouring temperatures.* Many speculations and false impressions are eliminated, enabling the technician to arrive at accurate analysis of casting defect causes.

The large **No. 752 HITEMP DILATOMETER** is designed for both routine sand control tests and for research tests on all molding and refractory materials.

AUTOMATIC CONTROLS provide precise temperature regulation, power input, rate of heating, rate of deformation, power specimen charging into furnace and atmosphere control.

SUITABLE FOR SPECIMENS 1⅛ inch or 2 inch in cross section. Range of test load is up to 6000 psi. for 1⅛ diameter specimen and 1890 psi. for 2 inch diameter.

WRITE FOR BULLETIN. *Also available upon request are reprints of articles presented before the A.F.A. on the subject of controlled molding materials at elevated temperatures.*

CONTROL EQUIPMENT SAVES TIME

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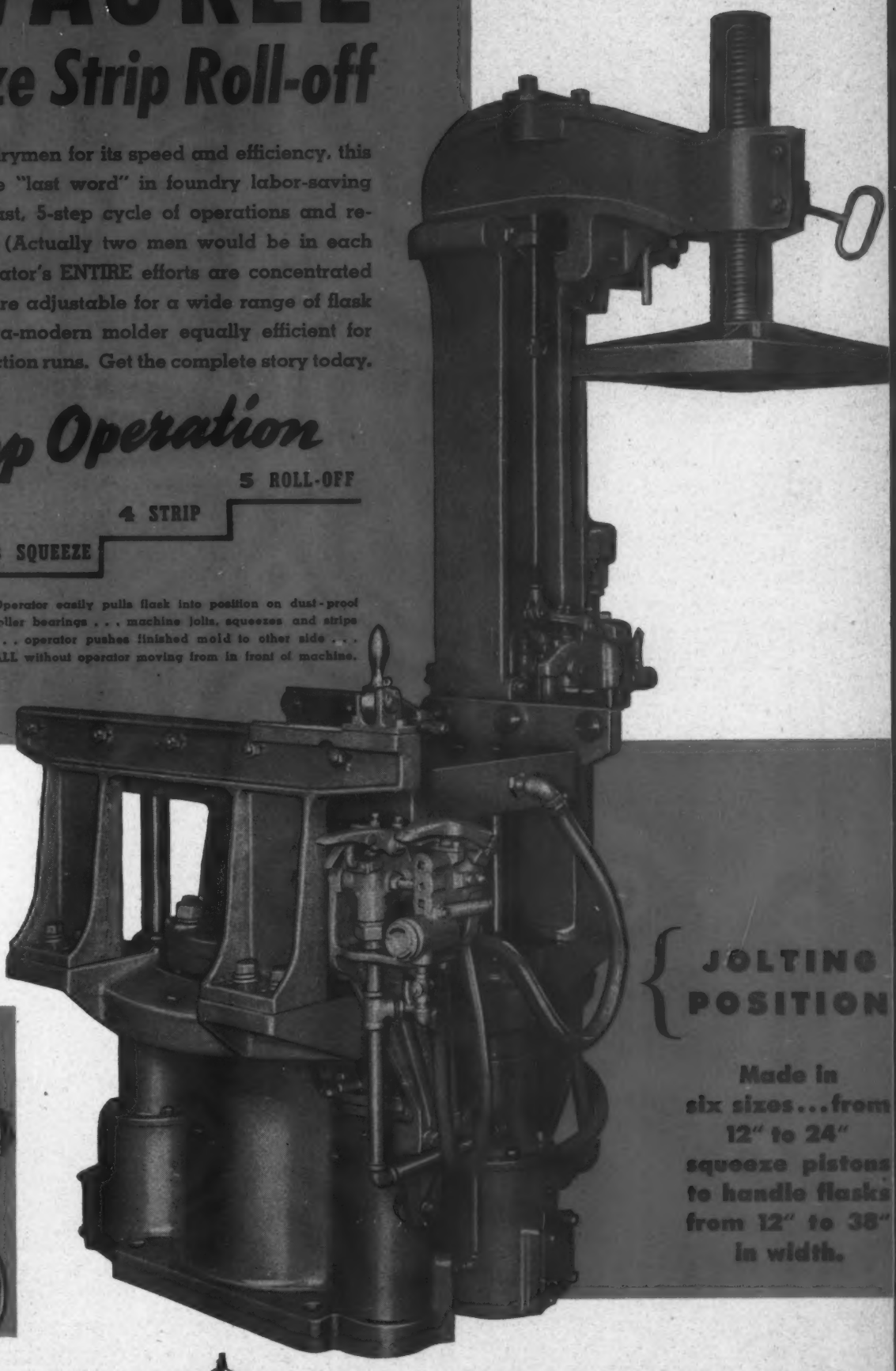
Jolt Squeeze Strip Roll-off

Acclaimed by leading foundrymen for its speed and efficiency, this new machine represents the "last word" in foundry labor-saving equipment. It provides a fast, 5-step cycle of operations and requires only ONE operator. (Actually two men would be in each other's way.) And the operator's ENTIRE efforts are concentrated on mold production. Rails are adjustable for a wide range of flask widths. You'll find this ultra-modern molder equally efficient for short run work or long production runs. Get the complete story today.

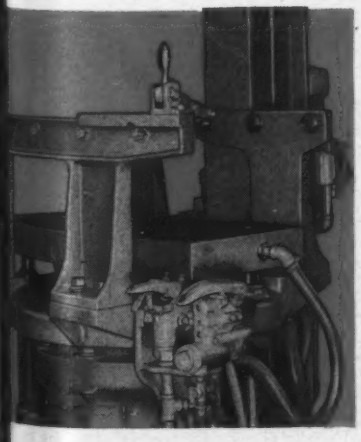
Fast 5 Step Operation

1 ROLL-ON
2 JOLT
3 SQUEEZE
4 STRIP
5 ROLL-OFF

Operator easily pulls flask into position on dust-proof roller bearings . . . machine jolts, squeezes and strips . . . operator pushes finished mold to other side . . . ALL without operator moving from in front of machine.



ROLL-OFF POSITION



{ JOLTING POSITION

Made in six sizes... from 12" to 24" squeeze pistons to handle flasks from 12" to 38" in width.

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How Is RECONVERSION Going With You?

Are you making a different class of work now since the war ended? Do these castings differ in size? in shape? in metal poured? in the finish required?

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What about profits? Do rising labor costs make it important that you cut sand costs?

Perhaps, with 22 years' specialized experience in this field, ECP can help you. We have five bonding clays (and their many combinations) from which to recommend the one right answer to your requirements. Note the "roll call" below; we'll be glad to send you carefully prepared technical literature on any of these ECP products.

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DIXIE BOND • BLACK HILLS BENTONITE • REVIVO BOND • REVIVO SUPER BOND • BALANCED REVIVO

All TYPES OF BONDING CLAYS

A Foundry Sand Service Based Upon Practical Research

Foundry Personalities

(Continued from Page 86)

● **M. E. Nevins,** formerly foundry superintendent, Ampco Metal, Inc., Milwaukee, and **Henry Seeboth,** who will remain as general manager, Milwaukee Bronze Casting Co., Milwaukee, have formed a new company to be known as The Whitewater Centrifugal Casting Co., Whitewater, Wis. Both men are active members of the Wisconsin chapter.

Albert Baron, Federated Metals Div., American Smelting & Refining Co., has been appointed purchasing agent of the Whiting, Indiana, plant.

● **Raymond Vines,** formerly with Ford Instrument Co., Inc., Long Island City, N. Y., is now metallurgist, Dentists Supply Co., York, Pa.

James L. Straight has been appointed Western Division Executive Director of National Patent Council, a new organization of smaller manufacturers launching a nationwide program in defense of the U. S. Patent System.

● **Dr. R. F. Thomson,** formerly with Dodge Chicago plant, Chrysler Corp., and a director of the Chicago chapter, has joined International Nickel Co., New York.

Gordon W. Monfort, formerly personnel director at "Caterpillar's" San Leandro, Calif., plant, has been appointed to the advertising department of the Caterpillar Tractor Co., Peoria, Ill., as director of the news bureau.

● **Joseph Edie** has been named branch manager of the Jessop Steel Co. at Indianapolis. Mr. Edie was formerly sales representative for Jessop in Cleveland. His headquarters will be in the Architects and Builders building.

Fred A. Melmoth, an A.F.A. Honorary Life Member and recipient of the Joseph S. Seaman Gold Medal in 1940, has moved from Birmingham, Mich., and will make Lake Leelanau, Mich., his residence.

D. F. O'Connor

F. L. Wolf

● **D. Frank O'Connor,** American Saw Mill Machine Co., Hackettstown, N. J., was elected Chairman, A.F.A. Brass and Bronze Division.

F. L. Wolf, technical director, Non-Ferrous Ingot Metal Institute, Chicago, was made Vice-Chairman.

Earl A. Swenson and **N. G. Phelps** have been appointed sales representatives for the Ironton Fire Brick Co., Ironton, Ohio. Mr. Swenson has the Ohio-Virginia territory and Mr. Phelps will have California.

● **Royden Rinker** has been engaged by the Pennsylvania Coal Products Co., Penacolite Div., Petrolia, Pa.,

(Continued on Page 108)

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SCHUNDLER BENTONITE

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From any one of the locations shown below . . . you can get prompt shipments of Schundler Bentonite . . . a first quality foundry Bentonite.

Akron, Ohio	Stoller Chemical Co.
Birmingham, Ala.	Foundry Service Co.
Boston, Mass.	Klein-Farris Co., Inc.
Buffalo, N. Y.	Weaver Materiel Service
Chattanooga, Tenn.	Ind. and Fdy. Equip. Co.
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Chicago, Ill.	B. J. Steelman
Chicago, Ill.	Wehenn Abrasive Co.
Cincinnati, Ohio	Delhi Foundry Sand Co.
Coldwater, Mich.	The Foundries Materials Co.
Detroit, Mich.	The Foundries Materials Co.
Dallas, Texas	Barada & Page, Inc.
Edwardsville, Ill.	Midwest Foundry Supply Co.
Hammond, Ind.	The Foundries Materials Co.
Houston, Texas	Barada & Page, Inc.
Kansas City, Mo.	Barada & Page, Inc.
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Los Angeles, Calif.	F. E. Schundler Bentonite Co. (Inc. of California)
Milwaukee, Wis.	Thomas H. Gregg Co.
Minneapolis, Minn.	Smith-Sharpe Co.
Moline, Ill.	Marthens Company
New Orleans, La.	Barada & Page, Inc.
Oklahoma City, Okla.	Barada & Page, Inc.
Philadelphia, Pa.	Penna. Fdy. Sup. & Sand Co.
Portland, Ore.	Miller & Zehrung Chemical Co.
St. Louis, Mo.	Midwest Foundry Supply Co.
San Francisco, Calif.	Industrial Supply Co.
Seattle, Wash.	Carl F. Miller Co.
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You are invited to consult us on any metallurgical problem. Specific products for specific results tested and improved through 18 years' practical experience.

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are scientifically blended—laboratory tested. *FLUXES* for melting, protecting, refining and degassing *aluminum, brass, bronze and grey iron alloys. A.B.C. FOUNDRATE FLUXES* assure *more* metal in the castings—*less* metal in the skimmings. Results are better castings at lowered costs.

A. B. C. MICA PRODUCTS

MICAWASH and MICAPARTE for core and mold washes—also parting compounds—for all ferrous and non-ferrous alloys. (Contain no free silica).

COATING COMPOUNDS for die casting—permanent molds—forging dies—centrifugal casting.

MICA LUBE supplies a clean, light-colored *Lubricating Film* suitable for *High Temperatures* without black smoke, dust or heavy fumes.

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180 Madison Ave., New York 16, N. Y.
Telephone: Ashland 4-2265-6-7-8-9

(One of the Tennant Group)

Foundry Personalities

(Continued from Page 107)

to do resin research. **E. Bowman Stratton, Jr.,** has been placed in special products sales development, and **Bill Swick** in adhesive sales.

K. L. Clark has joined the Detroit Gray Iron Co., Detroit, and is in charge of the cast to shape air hardening tool steel sales.

● **Isador Glueck** has retired from Federated Metals Div., American Smelting & Refining Co., after 31 years' service.

A. B. Pacheco, manager, Elena Rojas, V. de Pacheco, Santiago, Chile, was a recent visitor to the National office. He is an A.F.A. member.

● **Jean Montupet,** Fonderies Montupet, Paris, France, recently visited the National office.

K. G. Westin, A/B Westin & Backlund, Stockholm, Sweden, an A.F.A. foreign member, was a recent National office visitor.

● **R. Ronceray,** chairman and general manager, Ph. Bonvillain & E. Ronceray, Choisy le Roi, France, stopped to visit in the National office recently. Mr. Ronceray is the son of the late E. Ronceray, who was an A.F.A. medalist and an Honorary Life Member.

Jean-Jacques Baron, L'Aluminum Francais, Paris, was a recent visitor to the National office.

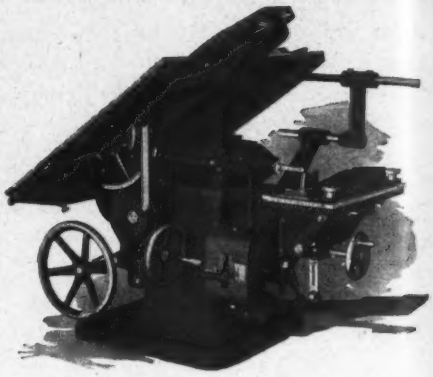
● **Williams & Hansen,** Industrial Management Engineers, announce that they have moved to new offices in the Commerce Building, 744 North 4th Street, Milwaukee.

Pennant Oil & Grease Co., Los Angeles, has been appointed far-western sales agent for Acheson Colloids Corp., Port Huron, Mich.

● **E. C. Kaufman,** I. Schumann & Co., Cleveland, has announced the purchase of a large tract of land at 4391 Bradley Road. A building program totaling $200,000, involving the construction of an office, warehouse and smelting plant, is planned.

(Concluded on Page 109)

"OLIVER"
Variety Saw Bench



For production of wood patterns

This compact, smooth-running "Oliver" Saw Bench rips, cross-cuts and dadoes. Cuts a perfect miter quickly and accurately. Has wide capacity. Dadoes up to 4" wide. Carries saws up to 18" diameter. Table tilts 45°, has 4" vertical adjustment. New saw guard offers utmost safety. Mortising and boring attachment available. Precision-built, and easy to operate.

Write for Bulletin No. 80D

OLIVER MACHINERY CO.
Grand Rapids 2, Michigan

HIGH SILICON IRON
"JISCO"
SILVERY

The choice of Foundries who demand the best.

"Jisco" Silvery is a "must" in the modern foundry. Its use means better castings at lower cost. It supplies the needed silicon.

Full information upon request.

● VIRGIN ORES
● LADLE MIXED
● MACHINE CAST

THE JACKSON IRON & STEEL CO.
JACKSON, OHIO

Foundry Personalities

(Continued from Page 108)

Velsicol Corp., Chicago, has opened a New York office in the Park-Murray Bldg., 9-11 Park Place, New York City 7.

• **Max Robbins,** General Manager, Federated Metals Div., American Smelting and Refining Company, announced the opening of a new physical testing laboratory at the Whiting, Indiana, plant.

Obituaries

David McLain, 82, died in Milwaukee, October 19. A well-known figure in the foundry industry, Mr. McLain was the organizer of the McLain System, Inc., Milwaukee, a correspondence course in mixing irons, cupola practice and semi-steel production. In 1936 at the A.F.A. Detroit convention he was awarded the J. H. Whiting Gold Medal for his many contributions to the progress of the foundry industry in the training of men and the stimulating of wide interest in better melting practice.

• **Irus H. Wells,** 84, died December 19. He was the founder of the Chicago Foundry Co., Chicago, and a member of the Chicago Foundry Club which later became the Chicago chapter of A.F.A.

Michael J. Powers, 92, for 45 years a representative of J. S. McCormick Co., Pittsburgh, Pa., died recently. He was the oldest foundryman honored at the Chicago chapter's "Old Timers" night last year.

• **John D. Cronenweth,** 64, Chairman of the Board, Great Lakes Foundry Sand Co., Detroit, died October 14 following a six weeks' illness.

William E. Kane, 79, founder and president, Kane & Roach, Inc., Syracuse, N. Y., died October 12. The late Mr. Kane also was a well known archaeologist and inventor.

• **Charles E. Walker,** New England representative and field engineer, Lancaster Iron Works, Inc., Lancaster, Pa., died November 11.

"Falls Brand" Alloys

Falls 50-50 Copper Nickel

FALLS 50-50 Copper Nickel has a lower melting point than pure nickel that melts at 2646° F. and is more soluble than pure nickel. It is, therefore, within the range of the average brass furnace and its introduction is possible without overheating the alloy.

Its principal advantages are:

Increased production
Reduced fuel consumption
Increased life of crucibles and furnace linings
Less rejected castings produced

And most important:

A Saving in Production Cost

Introduced at the beginning of a heat, it will be molten when the rest of the charge is liquid.
Used for the introduction of the definite amounts of nickel in making nickel base alloys. Used for "holding up" lead in high lead alloys.

"FALLS" 50-50 COPPER NICKEL
Produced in Shot Form

NIAGARA FALLS SMELTING & REFINING CORPORATION
America's Largest Producers of Alloys
BUFFALO 17, NEW YORK

HOFFMAN VACUUM CLEANING
WILL BRING YOUR FOUNDRY
DOUBLE BENEFITS!

★ **Hoffman vacuum equipment will pay you one dividend in elimination of dusts that are a health hazard. It will pay you another in savings in time and cost on production operations. Let us tell you about many applications in the foundry where specialized Hoffman vacuum equipment will bring you double benefits.**

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QUICK, ACCURATE
Temperature Readings in Non-ferrous Molten Metals with

XACTEMP
Hand Pyrometers

accurate to within a fraction of a scale division

The XACTEMP PYROMETER makes possible better quality control and helps toward elimination of blowholes, burnouts, sand infiltration and other flaws due to incorrect temperature . . . affords a simple, effective means for accurate temperature measurement of molten, non-ferrous metals. Well-balanced, easy to handle . . . always ready for use and requires no preliminary adjustments.

Cast aluminum and brass construction. Indicator is of medium resistance not affected by thermocouple length . . . acts rapidly . . . provided with Alnico V magnet and direct reading dial starting at 50° F. 43" stainless steel extension . . . standard 7" Marshall tip permits true readings below surface of metal. Made to give good service for years.

Catalog No. MM-701 Complete with Thermocouple $52.50

Catalog No. MM-7 Replacement Thermocouple Tip 7.00

Order at once to be sure of immediate delivery from stock.

Ask about XACTEMP PYROMETERS for all-around general temperature checking. A full line of thermocouples available in stock.

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